DOCUMENT RESUME

ED 027 591 24 CG 003 880

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Learning of Aurally Received Verbal Material. Including Comparisons with Learning and Memory Under Visual Conditions of Reception as a Function of Meaningfulness, Abstractness or Similarity.

Iowa Univ., Iowa City.

Spons Agency-Office of Education (DHEW), Washington, D.C. Bureau of Research.

Bureau No-BR-5-0318

Pub Date Mar 69

Contract-OEC-5-10-018

Note-96p.

EDRS Price MF-$0.50 HC-$4.90

Descriptors-*Audiovisual Instruction, *Aural Learning, *Aural Stimuli, *Concept Formation, *Information Seeking, Learning Processes, Learning Theories, Sex Differences

The objectives of this study were to determine: (1) the variables that influence the learning of verbal material received by subjects via the aural modality, (2) how learning under conditions of aural reception compare with learning of the same materials under appropriately equivalent visual conditions, and (3) in what combinations learning is affected by variously combined joint audio and visual presentation. Variables selected for consideration, in addition to reception mode, were meaningfulness, abstractness, and similarity. Subjects were undergraduate males and females at the University of Iowa, assigned randomly to treatments. The results of the 17 experiments conducted indicated: (1) with few exceptions, the same laws operate on the learning of verbal materials under both aural and visual conditions of reception, (2) a variable affecting visual learning will probably also affect aural learning, (3) sexual differences do not appear with respect to mode of input, and (4) it would appear that differences of performance as a function of input mode noted in this research are not to be viewed as having deep practical consequences for classroom learning. Tables are included. (Author/CJ)

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FINAL REPORT

Project No. 50318

Contract No. OE 5-10-018

LEARNING OF AURALLY RECEIVED VERBAL MATERIAL

INCLUDING COMPARISONS WITH LEARNING AND MEMORY UNDER VISUAL CONDITIONS OF RECEPTION AS A FUNCTION OF MEANINGFULNESS, ABSTRACTNESS OR SIMILARITY

March 1969

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

Office of Education
Bureau of Research

CG 003380

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Rudolph W. Schulz

March 1969

The research reported herin was performed pursuant to a Contract No. OE 5-10-018 with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

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Acknowledgements

This project could not have been completed without the truly devoted assistance of the personnel associated with it. Everyone worked hard! Especially so, at the times it was hardest to work because of the frustration produced by recurrent equipment malfunctions that slowed the progress of the project on several occasions. I am particularly indebted to Ronald H. Hopkins and Allen R. Dobbs who served as my research associates during the tenure of the project. The electronics expertise of Lloyd J. Frei was indispensible. Mrs. Mary Jane Snow and Mrs. Kathy Johnson provided the secretarial assistance which kept everything going. A number of outstanding undergraduates served as exceedingly capable research assistants. The University of Iowa has provided support for this project well beyond that which it agreed to provide under the provisions of the Cooperative Research Program.

Introduction

Background.--The importance of a comprehensive determination of the variables which affect learning via aural-verbal stimulation may be underscored by consideration of the central role which such stimulation plays in our life-long as well as day-to-day activities involving learning and communication which are part of educational procedures and processes. Indeed, until a child learns to read, he is singularly dependent on aural-verbal stimuli for the development of his language capabilities. Similarly, our formal educational procedures from the primary grades through college place heavy emphasis on learning from what we say in class. In addition, modern techniques for the teaching of foreign languages involve markedly increased use of aural-instructional devices--the language lab--and dependence upon learning from aural-verbal stimulation. Developers of self-instructional apparatus have also recently begun to be concerned with the possible advantages of devices which provide both aural and visual stimulation. Hence, it appears clear that detailed basic knowledge concerning the learning of aurally received material, comparisons of the learning of audio with visual presentation of material and the advantages and/or disadvantages of joint audio-visual presentation may have innumerable and significant potential applications in enhancing the effectiveness and efficiency of educational procedures. Moreover, such knowledge is also germane to the task of providing a comprehensive empirical description and articulate theoretical analysis of verbal-learning processes per se.

A survey of the extant research literature concerned with verbal processes and learning via aurally received stimuli at the time the present project was begun revealed that our knowledge regarding such learning was very incomplete and unsystematic. The perceptual capabilities of the aural modality had been investigated extensively with respect to both verbal (cf., Miller, 1951) and nonverbal (cf., Licklider, 1951) stimuli and were continuing to be investigated (e.g., Rubenstein and Pollack, 1963). Further, even though the main concern of these studies was not with aural factors, there had been at least some studies of short-term memory in which stimuli were received aurally (e.g., Broadbent, 1957; Peterson & Peterson, 1959; Keppel & Underwood, 1962). However, for reasons which were not immediately obvious, the learning of aurally received verbal material seemed to have received relatively little detailed attention. For example, Day and Beach (1950) undertook an exhaustive survey of the research literature prior to 1950 which might be relevant for this topic. They were evidently able to find only 34 research reports in the period 1894 to 1950 which dealt in even the remotest way (e.g., Burtt, H. E., & Dobell, E. M. The curve of forgetting for advertising material. Journal of Applied Psychology, 1925, 9, 5-21.) with this topic. Moreover, one study could not be systematically related to the others, these studies often had as a main concern processes other than acquisition (e.g., retention or cross-modality transfer, etc.) and they had most often been conducted prior to 1930. This state of affairs was not improved by consideration of the more recent research literature; indeed, if anything, there appeared to have been even fewer basic studies of the learning of aurally received verbal material since 1950 than prior to that year. By way of contrast, it was noted that there had been at least several hundred studies of the learning of visually presented materials since 1950 alone.

In short, it appeared clear that learning based on aural-verbal stimulation had not received the detailed and systematic attention which it deserves and that to have neglected this important topic represented an unfortunate short-coming of prior research in the area of verbal processes. The proposed project represented an attempt to begin to remedy this state of affairs.

Objectives of the research.--In gross terms, the purpose of this project was to seek answers to the following questions:

(1) What are the variables that influence the learning of verbal material when this material is received by S via the aural modality?

(2) How does learning under conditions of aural reception compare with learning of the same material under appropriately equivalent visual conditions?

(3) Is learning affected by variously combined joint audio and visual presentation? If so, what are some of the ways in which the two forms of presentation can be combined so as to produce optimally efficient performance under a given set of conditions?

It is evident from the above questions that the initial concern of this project was primarily with acquisition processes. Eventually, it was, of course, hoped that the scope of the project could be expanded to include consideration of transfer and retention, particularly from a cross-modal standpoint. The writer had been keenly alert to the significance of transfer and retention in the educational process for some time (cf., Schulz, 1960); however, in order to delimit the scope of the present undertaking so that it would retain manageable proportions, it was necessary to defer, with two exceptions, consideration of these important topics until some future time. Moreover, this deferment was seen as compatible with the fact that thorough knowledge of acquisition is almost a prerequisite for an intelligent investigation of transfer and retention. Similarly, among the three objectives, the first two were given priority over the third inasmuch as it seemed the question of joint effects could be entertained more meaningfully given attainment of the first and second objectives. Also, it is to be noted that since it was inevitable that the aural conditions of any study comparing visual with aural stimulation would provide data relevant for our first objective, most of our studies were designed to compare the auditory and visual modes of reception, as will be seen there were, however, a few exceptions.

Finally, as an aid in the formulation of hypotheses regarding possible differences in the processing, storage and retrieval mechanisms employed by S under the two modes of reception, an attempt was made within the context of the foregoing objectives to discover whether an effect due to modality, when present, would interact with other task (e.g., rate of presentation) or material (e.g., meaningfulness) variables.

A general methodological consideration.--Two comments seem in order here. First, among the major shortcomings of previous research in which comparisons of learning via the aural and visual modalities had been made was the failure to equate the duration of stimulation under aural and visual conditions. The duration of stimulation under visual conditions has usually exceeded aural stimulation by a considerable margin. Koch (1930) appears to have been among the first to recognize that equivalence of stimulation duration is a potentially crucial variable in such comparisons; however, there was little that she could do about it at the time because of the lack of suitable equipment which would insure the necessary equivalence of duration. Most investigators, even those making such comparisons recently (e.g., Gaeth, 1960; Lockard & Sidowski, 1961), had simply ignored this factor. Pimsleur and Bonkowski (1961) made an effort to equate durations by using short (1 sec.) visual exposures since they judged it took about 1 sec. to pronounce their words. This method does not, of course, achieve anything approaching a precise equation. Nevertheless, it is of interest that they found learning under aural conditions significantly superior to learning under visual conditions while Day and Beach (1950) reported that the reverse of this finding to be the more typical one in the studies they reviewed. On the other hand, Gaeth (1960) found, in different experiments, no difference, visual superior to aural and vice versa. At this point, however, it was impossible to know to what extent the lack of agreement among previous studies should be attributed to the failure to control stimulation duration, though it undoubtedly played a role, because these studies lacked comparability in so many other respects (e.g., type of material, type of task, presentation rates, etc.). In brief, the paucity of systematically related work precluded any meaningful, even tentative, generalizations.

It seemed essential in any attempt to compare learning as a function of mode of presentation that the duration of stimulation be equivalent for the two modes. Namely, it had been clearly established (e.g., Nodine, 1963) that performance is directly related to stimulus duration under visual conditions. Therefore, inasmuch as the duration of a given aural-verbal stimulus is necessarily of a more or less fixed length (unless it is repeated), it follows that visual stimulus durations which exceed this fixed duration must inevitably lead to superior performance quite aside from any effect due to the modality, per se.

The foregoing problem was solved by developing a sound-operated relay which permitted us to equate precisely the duration of stimulation in the two modes. That is, visual exposure durations were controlled by the duration of the articulation under aural conditions i.e., it was possible to expose visually a word, such as happy, for the exact length of time it took E to say, "happy" etc. Thus disequivalences in stimulus duration were eliminated as a confounding variable throughout the present research.

Second, it was recognized, of course, that the use of so-called "standard" verbal-learning tasks and materials might not have parallelled as directly as might be desired the kinds of learning tasks posed a student in the typical classroom situation. However, this limitation would seem to be a minor one when one considers the enormous amount of preliminary work that would have to be undertaken to scale selections of connected discourse, develop suitable tasks, and identify reliable dependent variables in attempting to devise an experimental situation which was a closer analog of the classroom. Furthermore, such a change would also have distinct disadvantages strategically because it would not permit one to utilize the large body of empirical and theoretical knowledge gained from previous research with these tasks and materials under visual conditions. Finally, since the concern of the present project was primarily with the identification of the fundamental underlying processes (i.e., encoding, storage and retrieval mechanisms) which operate under aural conditions of reception and differ from and/or have features in common with those operative under visual conditions, it did not seem, at least at this time, particularly crucial to attempt to simulate the inevitably complex conditions which obtain in the typical classroom situation.

Variables chosen for study.--In addition to reception mode (aural or visual), three other variables received systematic and detailed consideration. Two of these variables, meaningfulness and abstractness, represent attributes of verbal units. The third variable, similarity, refers to the relationships between units. In the case of similarity, three "versions" of it were considered: (1) Meaningful (synonymity) similarity. (2) Conceptual similarity. (3) Acoustic similarity.

These variables were chosen for two main reasons. First, they were known from previous research to produce substantial differences in performance in a variety of learning and memory situations, and/or there manipulation had interesting theoretical implications. Second, they seemed likely to be variables that would be encountered frequently in learning in educational settings. Similarly, a wide spectrum of task situations (including serial learning, paired-associate learning, free-recall learning, verbal discrimination, word association and short-term memory) was employed to maximize the likelihood that a variety of the aspects of learning in classroom situations would be adequately represented in our research. Also, in most of our studies, the sex of the Ss was a source of classification in the design. Lastly, there were a number of additional manipulations whose relevance can be explicated more effectively within the context of the particular study in which these manipulations were carried out; hence, they will be considered in appropriate contexts in the subsequent portions of this report.

Organization of the report.--As the preceding discussion indicates, the scope of the present research was rather wide ranging and included a diverse body of methods, procedures and empirical findings. It seemed necessary, therefore, to depart slightly from the recommended format for reports of this kind in order to optimize the chances of effective communication. Accordingly, those aspects of our methods and procedures which were common to most of the experiments conducted as part of this project will be described in the next section of this report. A third main section, the results section, will be divided into three subsections concerned with meaningfulness, abstractness and similarity, respectively. The purpose of the experiments reported in each subsection will be described briefly, details of method and procedure unique to a given experiment will be presented and, the results of each study will be described along with a preliminary interpretation of them. Finally, each subsection will be concluded with an overview of the findings making-up the subsection as a whole. The last main section of the report will be devoted to a discussion of the conclusions and recommendations which seem warranted based on consideration of the results of all the experiments which have been conducted during the tenure of the project.

General Method

Subjects.--All Ss were University of Iowa undergraduates who were either totally naive with respect to prior service in verbal-learning experiments or had not served previously in an experiment employing similar materials and procedures. The Ss were always assigned to treatments randomly with the restriction that the Nth S not be assigned to a given treatment until N--1 Ss had been assigned to each of the other treatments. An equal number of males and females were assigned to each of the treatments making up a given experiment except when constraints on the number of males and females in the S population precluded the assignment of an equal number of Ss from each sex. Hence, unless indicated to the contrary, it may be assumed that equal numbers of males and females were employed.

Procedure.--In all studies comparing directly the auditory and visual modes of reception, the verbal units were always presented sequentially, one at a time, under both aural and visual conditions. Pairing of stimuli, as in paired-associate (PA) learning, was accomplished by employing suitably discriminable differences in the lengths of the intrapair vs. interpair intervals. Sequential presentation was necessitated by the fact that the durations of the visual stimuli were always controlled by their aural counterparts so as to insure the desired equation of their durations. The latter involved having the auditory stimuli operate, via a Sony-777 tape recorder, a Farrall Instruments VR-3 sound-operated relay which, in turn, allowed a Dunning-Animatic filmstrip projector to be suitably programmed to present the visual counterpart of each auditory stimulus for the appropriate duration (cf. Schulz and Kasschau, 1966, for additional details). The visual stimuli were projected as a white image on a gray background from the rear onto a 1.5 x 2.5-in. gray Polacoat glass screen. The Ss received the aural stimuli from the tape recorder via headphones at an average loudness level of 50-55 db.

Results

Meaningfulness

Meaningfulness, hereafter abbreviated m, has been defined for 96 dissyllables by Noble and Parker (1960) as the mean number of written continued associations produced in 60 sec. by Ss in response to a given dissyllable stimulus. Some dissyllables are common English words (kitchen), others are paralogs (gojey). The latter look like a word, can be pronounced as if they were a word, but they will not be found in the dictionary. In terms of m, a dissyllable such as kitchen elicited, on the average, 11.72 associations. Its m is high. A dissyllable such as gojey has an m value of 3.26, making it a low-m unit.

Exp. I: Serial Learning and m (Schulz and Kasschau, 1966)

Serial learning has been of interest to investigators of verbal processes since the time Ebbinghaus initiated the study of memory under controlled conditions. Also, m was known to be among the most "potent" variables affecting the learning of verbal materials (cf., Underwood and Schulz, 1960). It seemed fitting, therefore, to begin our investigation of reception mode by determining the effect of aural vs. visual reception in serial learning with m varied through three levels encompassing the full range of the m scale.

Method.--The basic design was a 2x3 factorial arrangement of treatments, two modes of presentation of the stimuli (aural or visual) and three levels of m (low, medium or high). There were 126 Ss, 21 per condition, with a proportionate number of males and females in each cell of the design.

The three 12-item serial lists were the same as the ones used by Noble (1952). Their respective mean m, as determined by Noble and Parker (1960), was 3.19 (low), 6.46 (medium), and 9.98 (high). To enhance the generality of the present results, the items in each of these three basic lists were presented in three different orders, thus, there were nine lists.

The items had been recorded at a 2-sec. rate (as measured from the onset to onset of successive items) with a 4-sec. intertrial interval. All items were recorded in a uniform tone of voice except for a slight drop in inflection for the word REST. This word was presented at the onset of the intertrial interval to further differentiate the end of one trial from the beginning of the next.

Each S was read standard instructions for serial learning by the anticipation method which were appropriate for the conditions to which S had been assigned. All Ss were presented the list until they reached a criterion of one perfect recitation of the list. In the case of low m items, E accepted S's pronunciation of an item even if it was somewhat "bizarre" provided S used this pronunciation consistently.

Results.--Performance as a function of m and mode of presentation is shown in Fig. 1 in terms of the mean numbers of trials which were required to attain successive criteria. The most interesting feature of Fig. 1 is the clear evidence of an interaction between m and mode of presentation. Thus, with low m material, successive performance criteria were attained more rapidly under visual conditions of presentation than under aural conditions, but in the case of high m material this trend was reversed. Moreover, this interaction when evaluated in terms of the mean numbers of trials to reach a criterion of one errorless repetition of the list, easily meets the standards of statistical reliability, F (2, 120) = 4.80, $p < .01$. As was to be expected, m was a highly significant source of variation in performance, F (2, 120) = 40.32, $p < .01$, with the usual direct relationship between it and performance being readily evident from Fig. 1.

To assess whether the sex of Ss was a variable and/or whether it interacted with the treatments, the mean numbers of trials to reach criterion of male and female Ss were considered separately in each condition. There was no evidence that sex and treatments interacted. Under aural conditions, the means were 22.00 and 21.86 for males and females, respectively. The respective male and female means under visual conditions were 20.95 and 20.83.

The effect of mode of presentation on the serial-position curve was also determined at each of the three levels of m. Comparisons were made using a method suggested by McCrary and Hunter (1953) which is particularly well-suited for the purpose of assessing whether the shape of the position curve has been affected by a variable. This method involves consideration of relative performance as a function of serial position, the relative proportions of the total number of correct responses which occurred at each serial position under a given condition. An example of this type of comparison is shown in Fig. 2. The curves in Fig. 2 represent relative performance as a function of position and mode of presentation with low m material. As may be seen in Fig. 2, the relative distribution of correct responses with respect to position does not appear to have been altered by mode of presentation. This is true in spite of the fact that there were wide differences in absolute performance as a function of mode with this type of material. The curves for medium and high m material

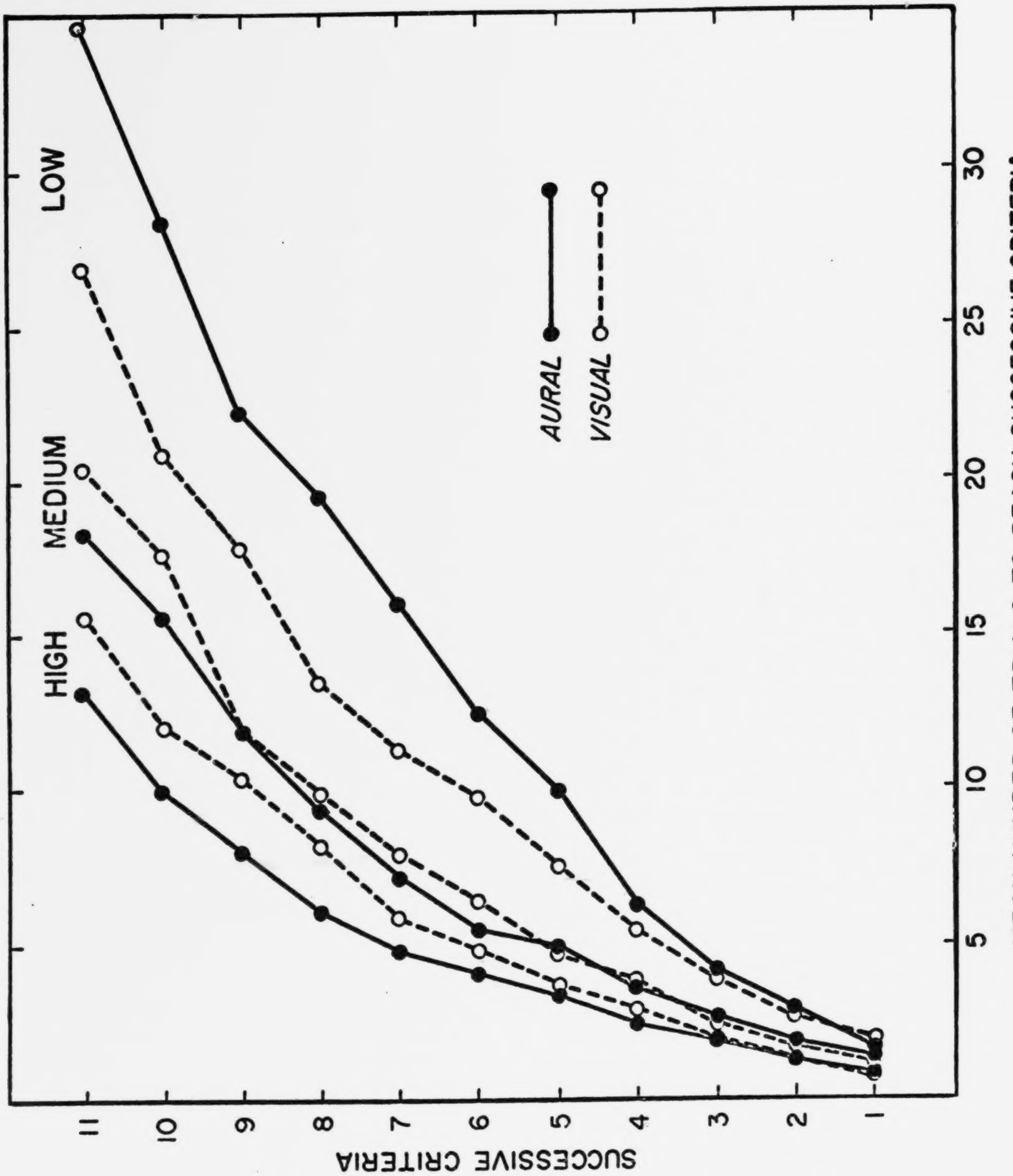


FIG. 1. Performance as a function of m and mode of presentation in terms of mean numbers of trials to attain successive criteria.

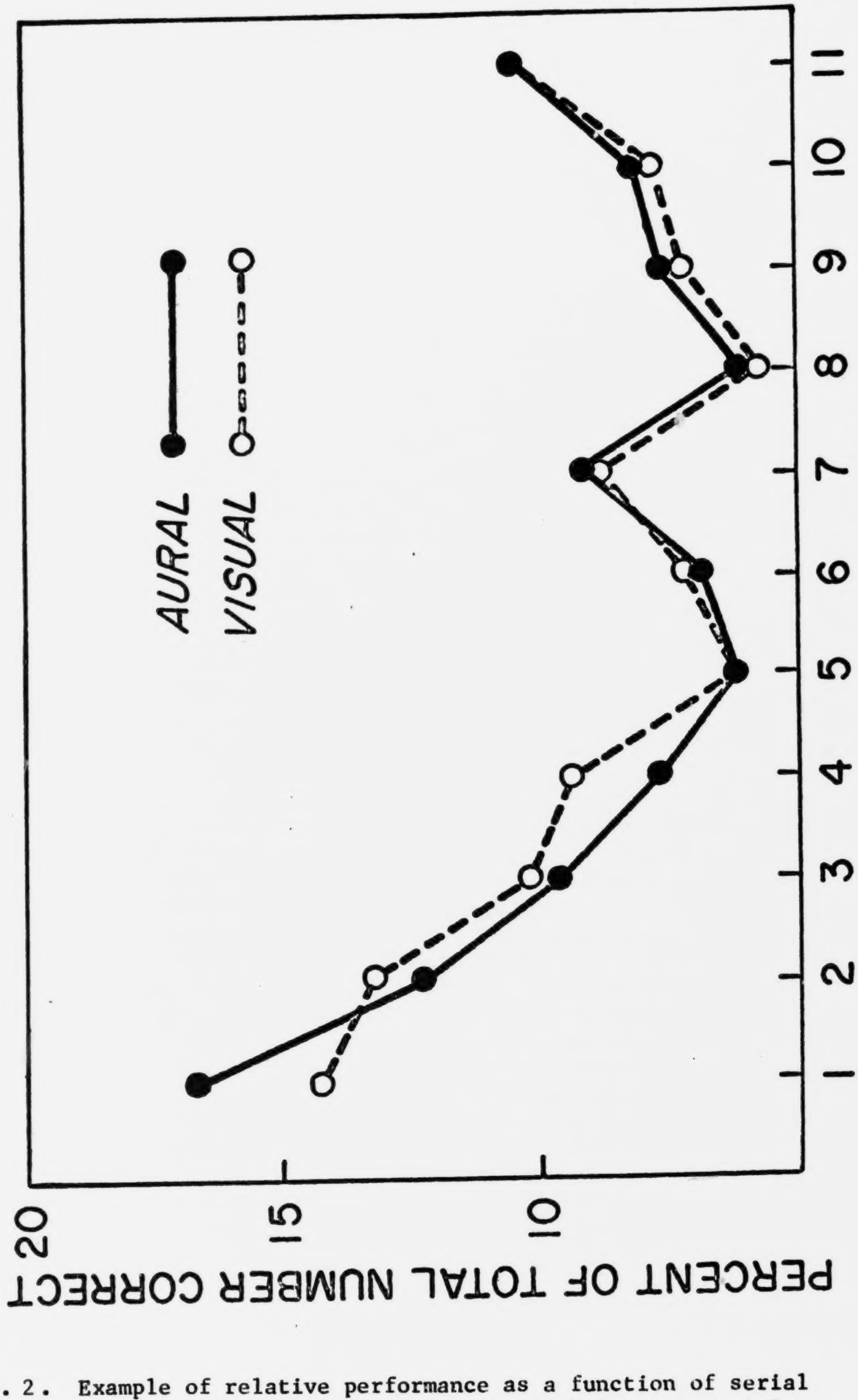


FIG. 2. Example of relative performance as a function of serial position and mode of presentation with low m material.

showed a similar null effect due to mode. Moreover, in agreement with McCrary and Hunter, m also failed to affect relative performance as a function of position.

Discussion.--It seems clear from the results of the present experiment that the learning of a serial list of low m material proceeds more rapidly when the list is presented visually rather than aurally. Contrariwise, there was a trend toward better performance under aural than under visual conditions when the lists consisted of medium or high m dissyllables. Interestingly, on the basis of an extensive survey of the pre-1950 literature on the present topic, Day and Beach (1950) concluded, in spite of numerous findings to the contrary, that "Meaningful, familiar material is learned more efficiently presented aurally, whereas meaningless and unfamiliar material is more efficiently presented visually [p. 8]." The present results are, of course, in close accord with this conclusion. Unfortunately, however, this accord may be little more than a matter of coincidence rather than further evidence supporting a fundamental generalization regarding the verbal-learning process. A recent study by Williams and Derks (1963) gives rise to this pessimistic view.

These investigators conducted a study similar to the present one in that, among other things, meaningfulness, defined in terms of association value (AV) and rated pronunciability (PR), was varied over three levels from low to high in conjunction with mode of presentation. Moreover, though durations of stimulation in the two modes were not equated directly as in the present study, the average durations were presumably similar in that a constant 1-sec. exposure (the average of the aural durations) was used under visual conditions. It was found that AV interacted with mode; however, the nature of this interaction was markedly different from the one observed in the present study. Namely, performance under visual conditions was superior to performance under aural conditions at the intermediate level of AV and PR but not at the low and high levels. Indeed, there was a nonsignificant trend toward better performance with aural than with visual presentation for material of low AV. There are, of course, a number of potentially important differences between the present study and the one by Williams and Derks, differences (e.g., the use of paired-associate rather than serial learning, CVC trigrams rather than dissyllables, etc.) which may make the foregoing comparison as tenuous as the previous one involving the present experiment and the wide assortment of studies reviewed by Day and Beach (1950). Nevertheless, and particularly in light of the fact that it is well established that the effects of m on paired-associate and serial learning are similar (cf., Underwood & Schulz, 1960), it is rather surprising that there should be such wide disagreement between these two studies with respect to the nature of the interaction of m with mode of presentation.

In short, it appears evident that it will be necessary to gain considerably more systematic empirical knowledge regarding mode of presentation as a variable in the verbal-learning process before undertaking the task of attempting to provide an explanation of its interaction with *m* in either the present or previous studies.

Exp. II: Paired-Associate (PA) Learning and m (Schulz and Hopkins, 1968a)

The first study in this series (Schulz and Kasschau, 1966) has shown that *m* and modality interact when the task is that of learning serial lists of 12 dissyllables by the anticipation method. With high or medium levels of *m*, performance was slightly better under aural than under visual conditions. This trend reversed itself with low-*m* materials in that performance under aural conditions was markedly inferior to that under visual conditions. The present experiment sought to determine whether a similar interaction would occur in PA learning. In addition, because of the analytic advantages of the PA task over the serial task, it was possible to manipulate stimulus (S)-term *m* independently of response (R)-term *m*. Thus, in terms of the two-phase conception of learning (cf. Underwood and Schulz, 1960) an interaction effect involving mode could, by virtue of its locus, be an aid in determining the extent to which the associative phase, the response-learning phase, or both are being affected by presentation mode.

Method.--The design was a 2x2x2 factorial with mode of presentation (aural or visual), S_m (high or low) and R_m (high or low) as the sources of treatment classification. The S_m and R_m treatments were defined within lists. A total of 64 *Ss* was employed, half under visual and the other half under aural conditions.

A basic list of 12 dissyllable pairs was constructed such that sets of three pairs represented the H-H, L-H, H-L, L-L S-term and R-term variations in *m*. The values of H and L in terms of *m* corresponded to those used by Schulz and Kasschau (1966), cf., Exp. I above. The particular items, in sets of three, representing a given level of *m* were counterbalanced with respect to S and R positions on the list and with respect to pair-type; hence, there were four "versions" of the basic list.

Learning was by the study-test method with *Ss* receiving 15 study and test trials in alternating fashion. On study trials, *S* studied (silently) the members of each pair as they were presented. The intrapair interval was 1 sec. The interpair and intertrial intervals were 2 sec. All intervals were measured from the onset of one item to the onset of the next. The pairs were presented in three different random orders. Presentation of the word *study* marked the beginning of each study trial, just as presentation of the word test identified the beginning of each test trial. Only the S terms of the pairs were presented on test trials at a 2-sec. rate while S attempted to recall, and say aloud, the R term associated with each of them. The Ss did not articulate the S terms. There were three different test-trial random orders of S terms.

Results.--The results of this study are summarized in Table 1 where test trial performance in terms of the mean total numbers of correct responses is shown for each of the eight respective conditions. The SDs for each condition also appear in Table 1. Two facts are strickingly apparent from Table 1. First, "input" modality had no effect on PA performance, $F < 1$. Second, neither S-term m nor R-term m interacted with modality; the largest of the two Fs barely exceeded unity. Inspection of the acquisition curves confirmed the absence of any Trial x Treatment interactions which would require qualification of the foregoing conclusions.

On the other hand, the now "classic" direct relationship between performance and level of S-term m and R-term m is clearly evident in Table 1 under both aural and visual conditions. The Fs (1, 62) of 97.11 for S-term m and 210.60 for R-term m are both significant, $p < .01$. In terms of the estimated variance attributable to variation in R- vs. S-term m, the effect of R-term m was 3.02 times greater than that of S-term m. The F for the interaction of these factors was less than unity.

As may be seen in Table 1, S's sex does not appear to have affected PA performance under either aural or visual conditions in any systematic fashion nor was it a statistically reliable source of variance either as a main effect or as an interacting variable.

To measure maintenance of correct responding under the various conditions, c/o ratios (cf. Schulz and Runquist, 1960, for a detailed description of this measure) were computed for each S (number correct after first correct/number of opportunities to give a correct response). There was a consistent trend, small in magnitude (a 3-5% difference) for correct responding to be maintained more readily under visual than under aural conditions for all four types of pairs. The latter finding is consistent with the fact that the overall means for total number correct were slightly greater under visual (110.44) than under aural (106.59) conditions. There was no evidence in the c/o ratio data that modality interacted with any other factor.

The relationship between performance under aural and visual conditions was assessed further for each of the four respective

TABLE 1

Means and SDs for Total Numbers of Correct Responses During 15 Trials of PA Performance as a Function of Mode of Presentation, S's Sex, S-Term m and R-Term m

R-term m			High				Low			
Mode of presentation			Aural		Visual		Aural		Visual	
N	S-term m	S's sex	Mean	SD	Mean	SD	Mean	SD	Mean	SD
16	High	Males	35.19	8.38	37.69	5.49	25.63	7.11	24.50	10.39
16	High	Females	35.63	6.36	36.50	7.50	22.44	10.39	26.88	8.73
32	High	Combined	35.41	7.33	37.09	6.49	24.03	8.91	25.69	9.51
16	Low	Males	32.63	6.51	28.44	8.77	19.06	10.52	17.56	9.84
16	Low	Females	27.38	8.80	31.25	8.45	15.25	10.95	18.06	10.34
32	Low	Combined	30.00	8.07	29.84	8.59	17.16	10.72	17.81	9.92

types of pairs by computing rank-order correlation coefficients based on the total number of correct responses for each of the 12 pairs of a given type under aural vs. visual conditions. These correlations are all positive and statistically reliable ($\underline{p} < .05$), except the one for H-L which approaches significance, and have the following values: H-H (.77), L-H (.81), H-L (.51), L-L (.70). Two trends may be noted in these data. First, low R-term m appears to reduce the magnitude of these correlations. Second, low S-term m seems to have the opposite effect in that it enhances the correlations slightly.

Discussion.--The conclusion which the present data demand seems clear; namely, input modality appears to have a very negligible effect on PA performance and does not interact with variations in either S-term or R-term m. Williams and Derks (1963) have obtained similar results with homogeneous lists of paired CVCs of the H-H or L-L variety. However, they found, in addition, that modality and m did interact in that CVCs of intermediate m were learned significantly faster under visual than under aural conditions. To check further on the accord between their data and ours, a follow-up study was conducted which involved an M-M list and the present materials and procedures. Modality failed to influence PA performance reliably, $\underline{t}(46)=.91$, $\underline{p} > .20$. The means for total number of correct responses were 81.67 and 89.46 under aural and visual conditions, respectively. Evidently then, the accord between the present results and those obtained by Williams and Derks is less than complete. Whether this lack of accord can be given a substantive interpretation remains to be determined.

Since Schulz and Kasschau (1966) observed an m by modality interaction in serial learning, the present failure to observe a similar interaction suggests a second-order interaction involving m, modality and task. Furthermore, since mode did not interact with either S-term m or R-term m, the present data are uninformative regarding possible differential mode effects on one or the other of the two phases of learning. Therefore, Exp.III had, among its other purposes, a further assessment of the role of mode relative to the two phases of learning.

Exp. III: Free-Recall Learning, Presentation Rate, and m (Schulz and Hopkins, 1968a)

The aim of the present study was severalfold. First, it represented a continuation of the empirical exploration of the role of modality in various task situations. Second, free learning may be regarded as representing the "purest" analogue of the response-learning phase. Thus, if the interaction between m and modality found by Schulz and Kasschau (1966) in serial learning involved the response-learning phase of the serial task, then a similar interaction should be observed here. Third, presentation rate on study trials was manipulated in an effort to determine whether information processing in the visual as opposed to the auditory system is affected differentially by input rate. For example, Mackworth (1964) in her studies of short-term memory (STM), using simple learning material (digits and single letters) has obtained evidence which suggests that a rapid rate may improve recall under aural conditions while recall under visual conditions is facilitated by a slow rate.

Method.--Two levels of each of the three independent variables were defined such that the design was a 2x2x2 factorial with $\underline{m}$ (high or low), mode (aural or visual) and rate (1 or 2 sec., onset to onset) as sources of treatment classification. Only $\underline{m}$ was varied "within-$\underline{S}$s." There were two equivalent lists of 12 Noble dissyllables, six of high and six of low $\underline{m}$ on each list. A total of 80 $\underline{S}$s was employed, with 20 in each of the four independent conditions.

The procedure was a slightly unorthodox one for the study of free learning because recall on test trials was paced with a light stimulus which was "flashed" every 2 sec. We were, however, attempting to parallel the response-learning phase of our prior serial and PA studies and, therefore, deemed pacing essential. There were six alternated study and test trials. The $\underline{S}$ listened or watched silently as items were presented on study trials. The items were presented in a different random order on each trial. On test trials, $\underline{S}$ attempted to recall, in any order, as many of the dissyllables as he could remember. A jewel light in front of $\underline{S}$ flashed 12 times, once every 2 sec. The $\underline{S}$ was to respond to each flash by giving a dissyllable; if more than one dissyllable was given during a 2-sec. response period, all those given were recorded. The $\underline{S}$s were encouraged to guess if uncertain. The two types of trials were identified by the presentation of the words study and test at the beginning of a trial.

Results.--The outcome of this experiment is summarized in Table 2 where the means and $\underline{SD}$s for the total numbers of correct responses over six acquisition trials are displayed for the various conditions. Modality does not appear to have been an effective variable, either as a main effect ($\underline{F}<1$) or as a source of interaction (all $\underline{F}s<1$). Performance did vary reliably ($\underline{p} < .01$) and in the expected manner, as a function of rate and $\underline{m}$. In addition these variables interacted, $\underline{F}$ (1, 76) = 4.77, $\underline{p} < .05$. As may be seen in Table 2, the difference in performance favoring the 2-sec. over the 1-sec. rate was considerably greater with low- than with high-$\underline{m}$ materials. Consonant with our previous observations, performance did not differ systematically as a function of the $\underline{S}$'s sex. The acquisition curves failed to show evidence of interaction between trials and treatments, a

TABLE 2

Means and *SD*s for Total Numbers of Correct Responses During Six Trials of Free Learning as a Function of Mode of Presentation, *m*, Presentation Rate and *S*'s Sex

m			High				Low			
Mode of presentation			Aural		Visual		Aural		Visual	
N	Presentation rate (sec)	*S*'s sex	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
10	1	Males	25.70	2.83	24.70	2.83	12.10	5.04	10.40	5.40
10	1	Females	25.00	3.62	25.20	4.31	13.10	5.00	15.10	5.86
20	1	Combined	25.35	3.18	24.95	3.56	12.60	4.91	12.75	5.99
10	2	Males	25.80	2.82	25.10	3.35	16.40	2.59	15.30	3.54
10	2	Females	26.60	2.72	27.10	1.97	17.30	5.38	16.50	4.67
20	2	Combined	26.20	2.73	26.10	2.86	16.85	4.09	15.90	4.07

possible exception being a slightly greater rate effect on Trial 1 than on subsequent trials with high-m units. Evidently then, if an effect due to "input" modality is to be found in the present data, a "finer grain" analysis will be required to reveal it. We turn now to some analyses of this variety.

We looked first at the relationships between performance and an item's serial position on study trials. These relationships, in terms of the number correct on all six trials, are depicted in Fig. 3 for the 1-sec. presentation rate. Two features of Fig. 3 seem noteworthy. First, the trend toward recency was clearly greater for low- than high-m items. Second, and most important in the present context, this recency effect appears more pronounced, particularly with low-m items, under aural than visual conditions. Unfortunately, it was not possible to treat these data statistically because m, while randomized, was not perfectly balanced over serial positions in the present mixed lists. The curves for the 2-sec. rate are similar to those in Fig. 3, except that effects associated with mode of presentation, including the differential recency trend in the low-m curves, are largely absent.

In a further analysis of the role of input position, we determined the point in the sequence at which S began his recall. Several interesting facts emerged from this analysis. First, Ss began their recall more often, 60.83% of the time, with a low-m item under aural than under visual conditions (44.07%) when the rate of presentation was rapid (1 sec.). At the slow rate (2 sec.), recall was begun more often with low-m items under both aural (55.00%) and visual (58.33%) conditions.

In addition, differential recency as a function of mode was again apparent in that, of those Ss beginning recall with low-m items, 67.12 and 56.62% did so with an item from Positions 11-12 under aural and visual conditions, respectively. The comparable percentages for high-m items were 48.94 (aural) and 33.33% (visual). Greater aural than visual recency no longer obtained at the 2-sec. rate; indeed, the trend for high-m items is reversed from what it was at the 1-sec. rate. The percentages for initiation of recall with items from Positions 11-12 were 59.09 (aural) 58.57% (visual) for low-m and 27.78 (aural) 40.00% (visual) for high-m items. Considering the "starting-point" functions overall, increased m and a slow rate of presentation tended to increase the degree of bowing in these functions; otherwise these functions were similar to those relating overall performance to serial position.

The last of the analyses, relating input to output, involved the determination of this relationship for each S individually on each trial. Kendall's tau (Kendall, 1948) was employed as a measure of the degree to which S's order of correct response output

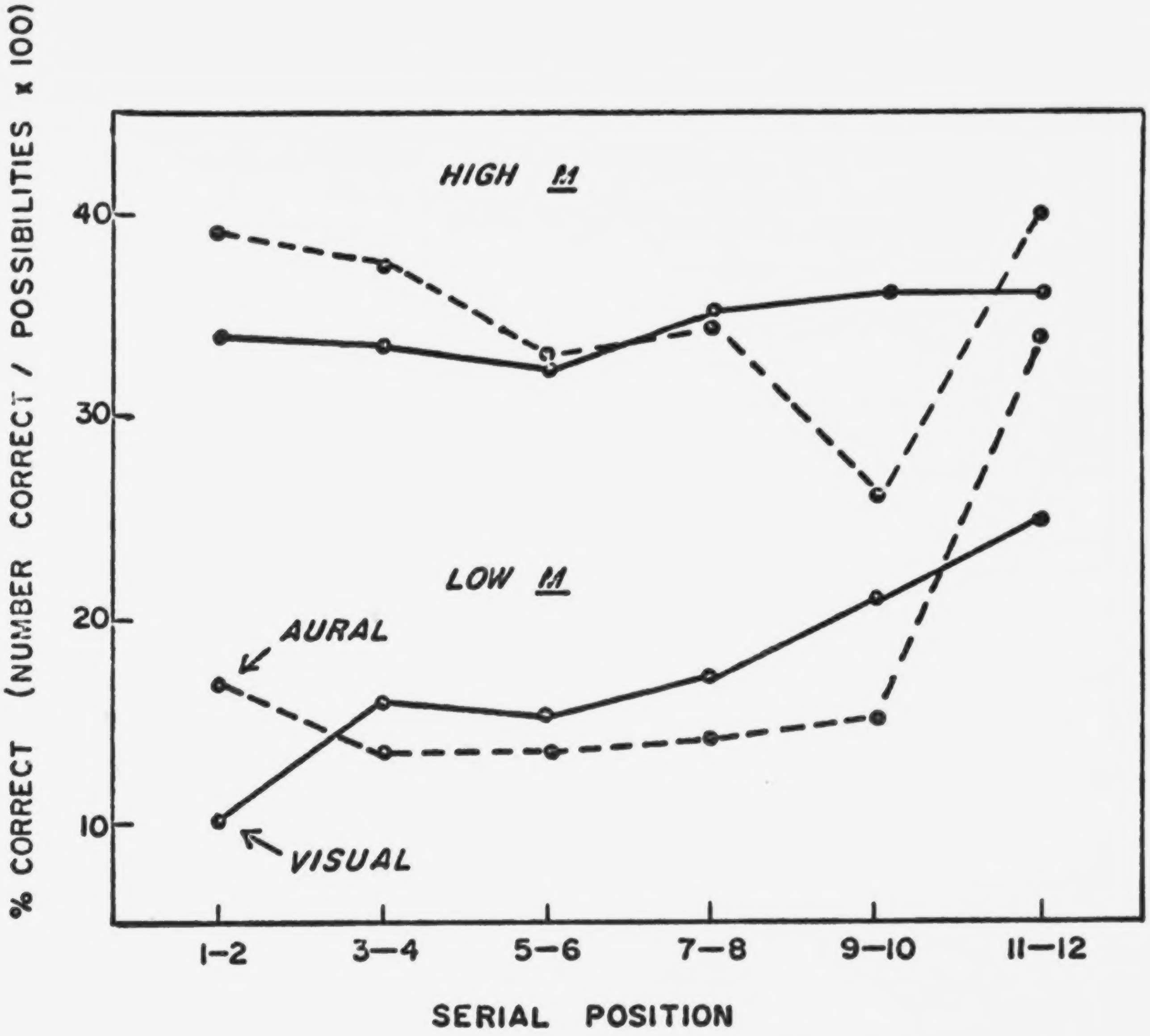


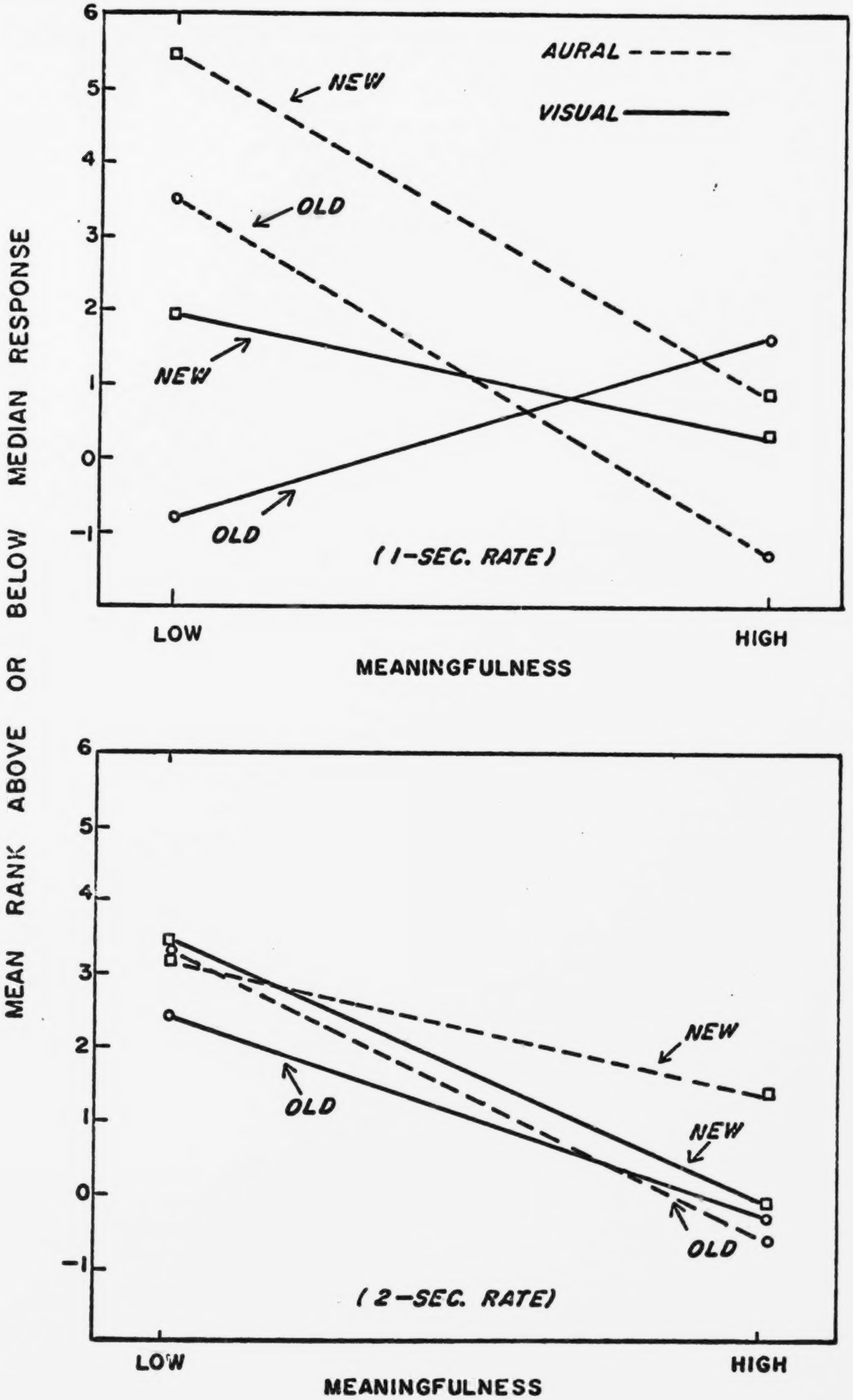
FIG. 3. Performance over six trials of free learning at a 1-sec. presentation rate as a function of m, presentation mode, and an item's serial position on study trials.

corresponded to the order of input for these items. It was not feasible to consider high- and low-m items separately. They were, therefore, combined. Also, failures to respond and overt errors were ignored in assigning ranks. The results of this analysis showed that input-output order correspondence decreased systematically as a function of trials under all conditions, the average tau being 0.21 on Trial 1 and -0.22 on Trial 6. But more importantly, and in accord with the preceding analyses, mode and rate interacted, $F(1, 76) = 8.15$, $p < .01$. The degree of input-output correspondence was significantly lower for Ss in the aural than for those in the visual condition at the 1-sec., $t(76) = 3.18$, $p < .01$, but not the 2-sec. rate, $t(76) < 1$.

The preceding analyses have dealt with the relationships between input and output order. What effect, if any, did the present treatments have on the output order, per se? Battig, Allen, and Jensen (1965) have recently developed a method for the analysis of priority in free recall which, with slight modification, seems suitable for use in attempting to answer the foregoing question. In brief, this is what was done. For each S on each trial, the median response (whether correct or an overt error) within that trial was assigned a rank of zero. The responses above the median response were then ranked +1, +2, +3, etc. so that the first response to be recalled received the highest positive rank. Similarly, responses below the median response were assigned ranks of -1, -2, -3, etc. with S's last response having the highest negative rank. Failures to respond were ignored in the rankings. The responses were than identified as to whether they were "old," having been given correctly at least once on a previous trial, or "new," having been given for the first time on that trial, and whether they were of high or low m. Next, the algebraic sum of the ranks of the responses in a given category (e.g., low m--new) was obtained and divided by the number of items involved to provide a mean rank. The latter step is obviously essential since the number of responses in a given category varied. Finally, a given S's "score" for purposes of analysis was the algebraic sum over trials of the means within a category. The means of these scores are displayed in Fig. 4.

As may be seen in Fig. 4, with one notable exception, low-m items were given earlier in the output sequence than those of high m, $F(1, 76) = 16.27$, $p < .01$. The exception is that old high-m items were given earlier than old low-m items under visual conditions at a 1-sec. rate. The latter reversal, coupled with the fact that the discrepancy in ranks of the low- vs high-m items under aural conditions is greater at the 1- than at the 2-sec. rate, combined to produce a significant Mode x Rate x m interaction, $F(1, 76) = 4.03$, $p < .05$. The trends ($p < .10$) toward a Mode x m and a Rate x m x Old-New interaction also appear to have been mainly the

FIG. 4. An analysis of the order of S's correct response output in free learning in terms of a given response's mean rank above or below the median response for that S on that trial with m, old (recalled previously) vs. new (recalled for the first time), presentation mode and rate of presentation as parameters.


MEAN RANK ABOVE OR BELOW MEDIAN RESPONSE
AURAL - - - - -
VISUAL ———
NEW
OLD
NEW
OLD
(1-SEC. RATE)
6
5
4
3
2
1
0
-1
LOW
HIGH
MEANINGFULNESS
NEW
NEW
OLD
OLD
(2-SEC. RATE)
6
5
4
3
2
1
0
-1
LOW
HIGH
MEANINGFULNESS

product of the foregoing reversal in the 1-sec. visual condition, although in the case of the latter interaction the reversal of the old and new points for low-m items in the 2-sec. aural condition also contributed. Lastly, although exceptions have already been noted, items not recalled previously tended to be given at the beginning of a trial while those recalled before were given later in a trial, $F(1, 76) = 6.54$, $p < .02$. In this regard, the present results affirm those reported by Battig *et al.* (1965). The mean rank of overt errors did not differ significantly as a function of modality, $F(1, 76) = 1.72$, $p > .10$, or rate, $F(1, 76) = 1.60$, $p > .10$. The F for the interaction of these factors was less than one.

As with PA learning, performance under aural conditions is correlated significantly with that under visual conditions. Using the total numbers of correct responses for each item as a base, but ignoring m, the rank-order correlations were slightly lower at the 1-sec. (.66) than at the 2-sec. rate (.73).

Discussion.--Performance as measured by mean total numbers of correct responses, failed to reveal mode of presentation to be a variable in paced free learning. This result has at least two implications. First, insofar as paced free learning is a suitable analogue of the response-learning phase of serial learning, it does not appear that the interaction between mode and m observed in our earlier study (Schulz and Kasschau, 1966) was due to mode having affected, at least overall, the response-learning phase of that task. Nevertheless, the finding of a nonadditive effect of mode and m on the order of item output argues for caution in regarding the foregoing conclusion to be an entirely firm one. Second, the absence of a modality by presentation-rate interaction would seem to constrain somewhat the generality of Mackworth's (1964) finding that rate and performance were directly related under aural and inversely related under visual conditions. Without detailing the evidence which prompts this assertion, certain of the present results suggest that, among the numerous differences in method and material employed by Mackworth and those used here, the "critical" differences were ordered vs. free recall and single vs. multiple trials. The plausibility of this assertion is clearly amenable to direct empirical scrutiny in further research.

Though modality had little effect on performance overall, it did affect performance at a more molecular level as revealed by detailed analysis "within" trials. In this connection, considering together the analyses of performance in relation to input position and the analysis of output sequence at a 1-sec. rate of presentation, it seems to be a tenable inference that *S*s process visually received information differently than they process the same information when it is received aurally. This view agrees with the one held by investigators of STM (e.g., Sperling, 1963; Murdock, 1966).

More specifically, there is evidence that short-term auditory storage may have a longer life than short-term visual storage (e.g., Mackworth, 1964; Murdock, 1966). It has also been found that cumulative rehearsal is less likely to occur under aural than under visual conditions (Corballis, 1966). Furthermore, Sperling (1963) has suggested that verbal rehearsal may be the mechanism through which visually received information is transferred from a temporary immediate visual store to a more permanent auditory storage. Rehearsal may, therefore, be less essential when the presentation is auditory in the first place and, if attempted, it may actually produce interference with newly and/or previously received aural information (cf. Corballis, 1966). The present situation is, of course, enormously more complex than those upon which the foregoing analysis is based. Nevertheless, there is considerable accord between the present data and the expectations generated by this analysis, at least when presentation was *rapid* (1 sec.). Thus, the fact that a greater recency effect was present under aural than visual conditions (Fig. 3) and that *S*s initiated their recall more frequently with low- as opposed to high-*m* items under both aural and visual conditions may have resulted either from the more rapid depletion of the aural than the visual short-term store of low-*m* items and/or from a combination of greater reliance on rehearsal under visual than aural conditions and the fact that rehearsal would undoubtedly be easier to accomplish with high- than low-*m* items. Similarly, in terms of the foregoing, it seems plausible that *S*s gave greater priority in recall (Fig. 4) to new low- than high-*m* items, as indexed by their mean rank in the output sequence, regardless of mode of presentation, and that this priority was greatest under aural conditions. The inversion under visual conditions of priority for high- over low-*m* items, when these items are old ones, is not, however, easily explained, except possibly as a manifestation of rehearsal. The higher degree of correspondence between the order of input and output under visual than aural conditions buttresses further the argument that rehearsal played a larger role under visual than aural conditions inasmuch as items presented at the beginning of a study trial could be rehearsed the longest.

Finally, if it can be assumed that a slower rate of presentation (2 sec.) attenuates the dependence on recall from a short-term store with both modes of presentation and increases the possibility for rehearsal under aural conditions, then the relative absence of "within-trial" effects due to mode at this rate is to be expected.

It is recognized, of course, that the foregoing interpretation involves considerable "extrapolation" and that it is completely *ad hoc*. Hence, it will be necessary to conduct additional research to establish further its tenability. In this regard, the direct manipulation under the present conditions, or suitably analogous ones, of the time an item has been stored, type of list (mixed vs.

homogeneous) and the opportunity for rehearsal seem particularly promising. It is also likely that the present interpretation may need to be supplemented, for example, to accommodate the possibility that Ss were able to encode low-m items more readily and in a more unitary fashion under aural than visual conditions because E provided a "standard" pronunciation for these items under aural but not under visual conditions. In any event, the present task appears to be a potentially productive one for the further investigation of the role of input modality in that a judicious choice of variables may permit one to magnify the present within-trials effects to a degree such that these effects will also become manifest in overall performance in terms of correct responding.

Exp. IV: Verbal Discrimination and m (Schulz and Hopkins, 1968a)

As in our previous studies, our aim here was to compare performance under aural with that under visual conditions of presentation while extending the sample of task situations in which such comparisons have been made to include verbal-discrimination learning. We knew of no previous studies in which this task had been employed under aural conditions.

As in our previous work, m was also varied. Again, its variation in the present situation has relevance for the two-phase conception in that, relative to the response-learning requirements in the tasks employed heretofore, the requirements for such learning, though not absent entirely, are reduced substantially here. Accordingly, if mode affected primarily the response-learning phase, a Mode x m interaction would not be anticipated. Thus, the present study paralleled the one performed previously by Runquist and Freeman (1960) with CVC trigrams and visual presentation in that m was either high or low and the members of a pair were either heterogeneous or homogeneous with respect to m.

Preliminary work with the heterogeneous-pair conditions revealed that Ss exhibited a "bias" in their choices, as inferred from performance on the initial trials, which favored the high-m members of the pairs. Runquist and Freeman (1960) encountered a similar problem when familiarized and unfamiliarized items were paired. Therefore, before beginning the experiment proper, a considerable amount of "pilot work" was undertaken in an effort to devise an appropriate set of instructions such that they would convince S that "correctness" in this task was purely an arbitrary matter and a "50-50 proposition." Having thought, at one point, that we were successful in this endeavor, we proceeded with the actual experiment; however, after these data had been collected, it became apparent that many Ss had continued, in spite of our detailed instructions to the contrary, to exhibit a bias favoring high-m items. Moreover, the presence of this bias was undoubtedly largely responsible for the fact that the within-*S*s variability was four times as great with heterogeneous as with homogeneous pairs (*m* was a within-*S*s variable in both cases). Furthermore, since it was not possible to determine, at least from the present data, to what extent this bias may have operated differentially under visual as opposed to aural conditions, (e.g., the inflation of the within-*S*s variability was even more pronounced in the latter than the former of these conditions) it is difficult to know how to interpret these data. Hence, only the homogeneous-pair conditions will be considered further here.

Method.--Again, treatments were arranged factorially, with the classification of these treatments being in terms of *m* (high or low) and modality (aural or visual). The *m* level varied within-*S*s while modality was a between-*S*s variable. A total of 40 *S*s participated; of the 20 *S*s per group, half were males and half females.

The basic list contained a total of 16 pairs, eight H-H and eight L-L pairs. There were four random orders of pair presentation and the within-pair ordering of the items was randomized with the restriction that each member of a pair was presented first twice and second twice over a block of four trials. Finally, to counterbalance item difficulty, one member of each pair was correct for half the *S*s in each condition while the other member was correct for the other half of the *S*s.

Aural conditions of necessity required sequential presentation whereas heretofore simultaneous presentation has been most commonly employed. The inter-pair interval was 2 sec. with a 1-sec. intrapair interval and a 2-sec. intertrial interval. All intervals are defined in terms of the time from the onset of one item to the onset of the next. After *S* had heard (or seen) both members of a pair, he responded during the interpair interval by saying aloud the item he thought to be the correct one. The *E* sounded a buzzer only if *S* responded correctly. A total of 16 such trials was administered to all *S*s. The *S*s were strongly encouraged to guess so that they would respond every time a pair was presented.

Results.--The results are summarized in Table 3. The means presented there represent the total numbers of correct responses given during 16 trials of acquisition. Focusing first on the combined means, two trends are apparent. First, performance with high-*m* pairs was superior to that with low-*m* pairs, $F(1, 36) = 14.54$, $p < .01$. Second, and of greater interest, *m* and modality appear to have interacted such that performance under aural conditions was slightly better than under visual conditions with high-*m* materials, but with low-*m* materials it is the visual condition that was superior to the aural one, $F(1, 36) = 5.77$, $p < .025$. A similar trend is apparent from the tabulation of those *S*s reaching

TABLE 3

Means and *SD*s for Total Numbers of Correct Responses During 16 Trials of Verbal Discrimination Learning as a Function of Mode of Presentation, *m* and *S*'s Sex

Mode of Presentation			Aural		Visual	
Level of *m*	*S*'s sex	N	Mean	*SD*	Mean	*SD*
High	Male	10	91.40	9.46	97.00	16.46
High	Female	10	105.80	17.41	98.10	11.62
High	Combined	20	98.60	15.49	97.55	13.86
Low	Male	10	80.30	8.92	97.10	13.64
Low	Female	10	98.40	16.52	93.80	12.64
Low	Combined	20	89.35	15.91	95.45	12.88

an 8/8 criterion and those who failed to do so. Nine *S*s failed under aural conditions to attain this criterion with low-*m* items while only four failed under visual conditions. In the case of high-*m* items, three and five *S*s failed to attain the criterion under aural and visual conditions, respectively. Turning now to the means for males and females, we find at both levels of *m* that males performed better under visual than aural conditions while in the case of females the reverse was true. Moreover, it appears, statistically, unlikely that this interaction occurred by chance, $F(1, 36) = 4.57$, $p < .05$. Inspection of performance as a function of trials revealed that the foregoing trends are present throughout acquisition.

The mean total numbers of correct responses have been plotted in Fig. 5 as a function of conditions and the position (first vs. second) of the "correct" pair member. It is evident from Fig. 5 and statistically demonstrable, $F(1, 38) = 53.29$, $p < .01$, that performance was consistently better when the correct member of a pair was the *second* rather than the first member of the pair to be presented. Moreover, position and *m* interacted such that the decrement associated with the correct member being first was greater for low- than for high-*m* pairs, $F(1, 38) = 5.32$, $p < .05$. This interaction seems to be due mainly to *m*'s ineffectiveness when second-position items were correct in the visual condition. The interaction between mode and *m* is apparent for both positions,

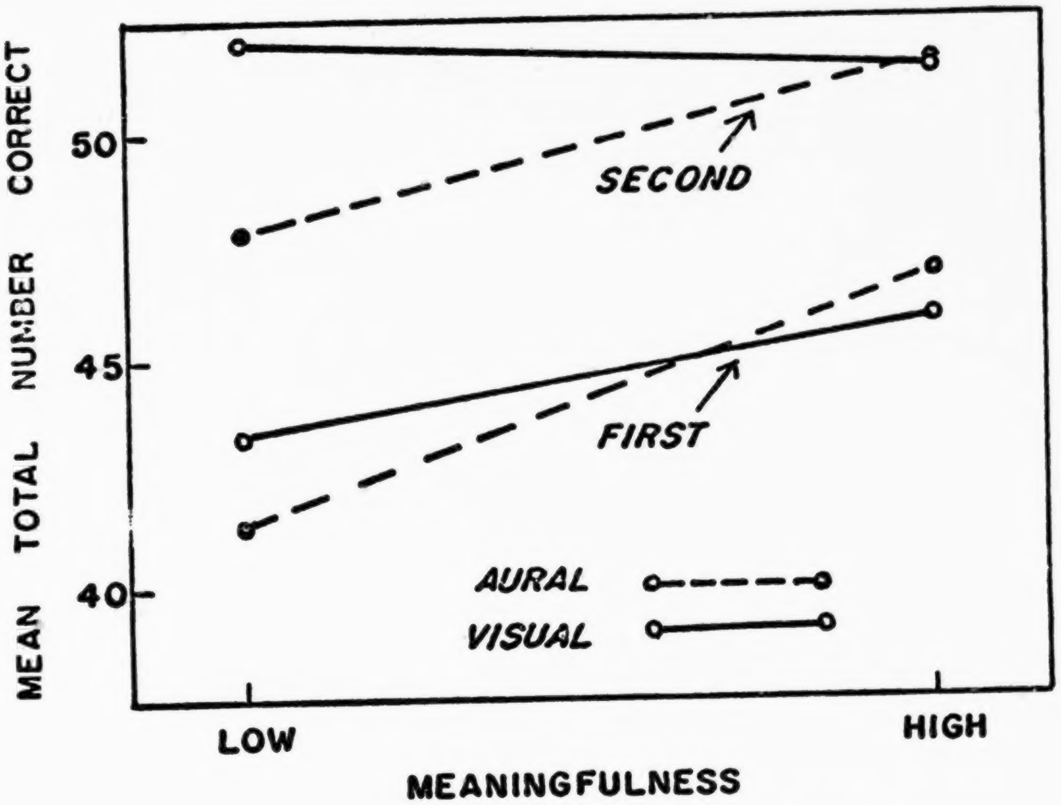


FIG. 5. Mean total numbers of correct responses in 15 trials of verbal discrimination learning as a function of the position of the "correct" pair member, m, and mode of presentation.

$\underline{F}(1, 38) = 5.79$, $\underline{p} < .05$. Although this interaction appears to be more pronounced for the second than the first position, statistically the trend toward a second-order interaction is not a reliable one.

The rank-order correlation of .36 between item ranks in terms of total number correct under aural vs. visual conditions is lower than any we have observed thus far.

Discussion.--The most interesting feature of the present results is that they appear to parallel those obtained in the serial-learning situation; namely, performance under aural conditions with low-$\underline{m}$ units was inferior to that under visual conditions while there was little difference between these two conditions with high-$\underline{m}$ units. This interaction comes about in the present study because $\underline{m}$ was an ineffective variable under visual conditions, $\underline{t}(18) = 1.00$, $\underline{p} > .10$, but not under aural conditions, $\underline{t}(18) = 4.40$, $\underline{p} < .01$. Moreover, the presence of this interaction favors the interpretation that mode has its effect on the associative and not the response-learning phase of a task.

Consideration of the results of the analysis of performance as a function of the position (first vs. second) of the "correct" pair member shows that $\underline{m}$'s ineffectiveness in the visual condition is most apparent when the second member of a pair was the correct one (Fig. 5). One way of interpreting these results is to hypothesize that from the standpoint of STM high-$\underline{m}$ items may be more susceptible to proactive inhibition than low-$\underline{m}$ items when the presentation is visual but not when it is aural. A similar interpretation involving retroactive inhibition may be applied to the smaller differences as a function of modality observed when the correct pair member was presented first.

The present failure to observe an $\underline{m}$-related decrement in performance in the visual condition seems to be in accord with Runquist and Freeman's (1960) results for homogeneous pairs of trigrams where they found only a marginally significant and relatively small decrement associated with a decrease in $\underline{m}$. Actually, however, if one can assume that the "absolute" differences in $\underline{m}$ were comparable in the two studies, then one might have expected the effects of $\underline{m}$ to have been greater in the present than in Runquist and Freeman's study. This expectation arises from the fact that pair presentation was simultaneous in their study and successive in this one; hence, short-term memory and, in the case of low-$\underline{m}$ pairs, response learning were undoubtedly more prominent factors in our study than in theirs. Yet, insofar as comparison is possible, since Runquist and Freeman do not report mean total numbers of correct responses, it seems $\underline{m}$ had a greater effect in their study than in this one in that 85% of their Ss are reported as having reached an 8/8 criterion sooner on high- than on low-$\underline{m}$

pairs while only 60% of ours did so in the visual condition. However, if it is assumed that PI and RI affect performance in the present task when presentation is successive but not when it is simultaneous--an assumption that seems reasonable--then the hypothesis advanced earlier regarding differential susceptibility to PI and RI of visually presented items could account for the fact that *m* may have been a more effective variable in Runquist and Freeman's study than in this one.

One additional facet of the present results seems worthy of consideration. It will be recalled that *S*'s sex and presentation mode interacted in the present study. This is the first time such an interaction has emerged in the present series of studies and, as a result, it is difficult to develop a meaningful interpretation of this finding. The best course of action would seem to be, therefore, the one of awaiting the possible emergence of a similar interaction in subsequent work in the hope that these subsequent findings will help to clarify the interpretation of the present one.

Exp. V: Free-Association and m (Schulz and Hopkins, 1968b)

A recent review of research concerned with the factors affecting performance in word-association tasks by Jung (1966) reveals that mode of presentation has not received a great deal of attention. Moreover, it does not appear that duration of stimulation has been equated in previous comparisons (Buchwald, 1957; Rosenzweig, 1961). Since it is well established (cf. Woodworth and Schlosberg, 1954) that reaction time plays an important role in the word-association task, a difference in duration of stimulation could be a critical factor. Furthermore, with respect to the definition of *m*, it may be noted that it is based on the mean *number* of associations rather than the *nature* of the associations a given dissyllable elicits, *S*'s associative hierarchy; yet, it seems quite likely that not only is the number of associations an important determiner of performance in verbal-learning situations but that the *kinds* of association may play a role as well.

The present study was undertaken to determine *S*'s associative hierarchy in relation units varying in *m*. Moreover, this study appears to have been the first to undertake such a determination. Therefore, the data obtained here, were not only of empirical interest, but it was also anticipated that they would have implications for the interpretations of *m*'s effects on performance in the verbal-learning situation. For example, insofar as *S*'s employ mediating associations in learning a list of paired associates varying in *m*, the degree of associative overlap among the dominant responses to the paired-associates stimuli would be expected to be a potentially important determiner of the amount of interference that might be encountered among mediators. Similarly, if *S*'s associative hierarchy is such that the dominant responses elicited by aurally received stimuli differ from those elicited by visually received stimuli, then inferences regarding *S*'s associative tendencies under a given set of conditions must take into account the mode of stimulation being employed (e.g., to study mediation involving *S*'s existing habits).

Method.--All of the 96 dissyllables scaled for *m* by Noble and Parker (1960) were used as stimulus materials. In addition, six practice words (HUB, AWK, WHELK, GOLF, DRUM, THAPES) were selected from Cieutat's (1963) list of monosyllables. Five lists, each a different random order of the 96 dissyllables, were prepared with the restrictions that in no case did three successive items come from the same sixth of the *m* dimension, and no dissyllable appeared in the same position in any two of the lists.

The lists were recorded, in a male voice, using a Sony 777 Series magnetic tape recorder. A parallel 16 mm. filmstrip of each list was also prepared. In the aural condition (Cond. A) the stimuli were presented to the *Ss* via a loudspeaker. For *Ss* in the visual condition (Cond. V) the stimuli were projected on a beaded screen.

The *Ss*, in small groups of 3 to 10, were seated 5 to 8 ft. from the screen. Each *S* was provided with a response booklet containing approximately 28 equally-spaced blanks per page, centered and numbered serially from 1 to 96. In addition, there were six practice blanks at the top of the first page of the booklet. The *Ss* were instructed to respond to *each* stimulus by writing, on the appropriate blank, the first word it made them think of. The *Ss* were cautioned not to give the stimulus as a response or to perseverate in giving the same response to successive stimuli. To keep the responses as independent as possible, the *Ss* were provided with a file card with which they were instructed to cover their previous responses, sliding the card down the page as the experiment proceeded. Pilot work had shown that, with the help of the six practice words, the *Ss* would be able to pace themselves, and therefore no warning signal, before stimulus presentation, was provided.

The stimuli were presented, one at a time, at a 6-sec. rate (onset of one stimulus to onset of the next stimulus), until the 6 practice words and all 96 test items had been presented. The one exception to the continuity of this procedure was that after item numbers 8, 16, 30, 44, 58, 72, and 84, there was a 12-sec. inter-item interval in which *E* reminded the *Ss* of the proper location in the response booklet and, if required, asked them to turn the page.

A total of 259 *S*s was used. The *S*s were assigned randomly to Cond. A and V and the lists representing different orders of item presentation. The data for 21 *S*s had to be discarded because of equipment failures. In addition, the data of 38 other *S*s were discarded because these *S*s failed to respond to six or more of the stimuli. Unfortunately, the tendency to omit responses was greater in Cond. V (32 *S*s) than in Cond. A (6 *S*s); hence, the *S*s in Cond. V represent a sample which is perhaps biased slightly with respect to some dimension of task.

Though this problem was not encountered in our pilot work, it seems, nevertheless, to have been a simple matter of *S*s in Cond. V not having seen the stimulus word when it was presented. When the durations of the aural and visual stimuli are equated, the durations of the stimuli are necessarily quite brief, 500 to 600 msec. Therefore, the demands of the task on *S*'s attention were undoubtably greater in Cond. V than in Cond. A since the former required *S* to look at the stimulus on a screen while the latter did not. The use of a ready signal in future work of this kind would probably eliminate this problem. In any event, it appears unlikely that the bias in the present data is a serious one since comparison of the response protocols of the dropped *S*s with those of the *S*s who replaced them failed to reveal any obvious differences between these *S*s.

The analyses to be reported subsequently are based on a sample of 100 *S*s, 54 females and 46 males, in Cond. V and A, the total number of *S*s being 200.

Results and Discussion.--To permit a contrast of the degree of commonality between the responses elicited under Cond. V with those elicited in Cond. A, the primary and secondary associations to each stimulus along with their respective frequencies of occurrence are presented in Table 4 as a function of conditions and *m*. The maximum possible response frequency for each stimulus in each mode is 100. Inspection of Table 4 reveals that identity of primary and secondary associates in the two modes is a direct function of *m*. For the 16 stimuli having the highest *m* value, 94% have identical primary associates and 56% have identical secondary associates. The comparable percentages for the 16 stimuli having the lowest *m* values are 12% and 0%, respectively. This relationship has been quantified further by means of a measure of commonality (C). The computation of this index, shown in the last column of Table 4, can be illustrated by means of an example. Suppose ROCK has occurred as an associate to QUARRY 13 times in Cond. A and 10 times in Cond. V, and that STONE was given 8 and 17 times, respectively, in the two conditions; then if there were no other common associates, C for the stimulus QUARRY would equal 18 (10 + 8). Thus, the value of C could range from 0 to 100. As may be seen in Table 4, C

TABLE 4

Primary and Secondary Associations and Their Frequency of Occurrence (f_p and f_s, respectively) for Each Modality, Number of Responses with Frequency of One (N_1) to Each Stimulus in Each Modality, and Number of Responses to Each Stimulus Identical in Both Modalities (C)

Stimulus	Modality Stimulus m	Aural					Visual					
		Primary	f_p	Secondary	f_s	N_1	Primary	f_p	Secondary	f_s	N_1	C
KITCHEN	11.72	Sink	29	Food	14	20	Sink	25	Food	13	21	67
ARMY	11.27	Navy	31	Man(men)	16	16	Navy	48	Man(men)	7	20	58
MONEY	10.87	Dollar(s)	12	Coin(s)	11	22	Cash Dollars	10	Rich	8	39	49
GARMENT	9.96	Clothes	42	Dress	17	13	Clothes	42	Clothing Dress	9	22	77
HEAVEN	9.94	Hell	46	God	12	21	Hell	55	God	14	16	73
DINNER	9.93	Supper	30	Food	19	14	Supper	24	Eat	22	14	77
WAGON	9.90	Wheel(s)	42	Red	19	14	Train	31	Wheel(s)	29	19	57
OFFICE	9.77	Work	18	Desk	15	19	Work	15	Desk Room	7	29	53
INSECT	9.56	Bug(s)	54	Ant	12	17	Bug(s)	47	Fly(ies)	9	19	70
ZEBRA	9.34	Stripe(s)	31	Horse	21	14	Stripe(s)	29	Animal	23	11	78
JEWEL	9.33	Diamond	22	Gem	19	16	Diamond	28	Ring	9	31	58
JELLY	9.29	Jam	20	Jello	11	27	Jam	36	Fish Peanut butter	8	10	58
VILLAGE	9.11	Town	44	City House(s) People	6	21	Town	53	House(s)	6	20	69
YOUNGSTER	8.95	Child(ren)	48	Kid	16	18	Child(ren)	42	Kid	14	14	72
TYPHOON	8.93	Storm	35	Wind(s)	24	20	Storm	36	Wind(s)	22	16	71
CAPTAIN	8.57	Ship	26	Leader	11	26	Ship	33	Leader	11	23	64
INCOME	8.40	Money	53	Tax(es)	13	15	Money	53	Tax(es)	24	18	75
HUNGER	8.35	Food	24	Pain(s)	23	13	Pain(s)	29	Thirst	20	12	80
LEADER	7.94	Follower	14	Follow	9	30	Follower	20	Captain Follow Head	7	26	59

TABLE 4
(Continued)

Stimulus	Modality Stimulus $\underline{m}$	Aural					Visual					
		Primary	f_p	Secondary	f_s	N_1	Primary	f_p	Secondary	f_s	N_1	C
FATIGUE	7.88	Tired	72	Tire	4	20	Tired	72	Sleep	6	20	77
UNCLE	7.82	Aunt	70	Sam	6	10	Aunt	62	Man	8	20	77
QUARTER	7.76	Money	22	Dime	14	25	Dime	28	Money	18	11	57
KENNEL	7.50	Dog(s)	89	Animal(s) Kennel Ration	2	5	Dog(s)	79	Kernal	5	11	84
REGION	7.49	Area	56	Place	10	20	Area	46	Place	8	28	64
ZERO	7.47	Nothing	50	None	14	11	Nothing	33	None	15	23	67
QUARRY	7.33	Rock(s)	40	Stone(s)	12	31	Rock(s)	25	Stone(s)	11	43	53
MALLET	7.27	Hammer	38	Croquet	10	21	Hammer	36	Ball	15	20	69
UNIT	7.16	One	31	Group Single	6	32	One	50	Group Number	6	22	52
ZENITH	7.15	Television(TV)	28	Radio	11	16	Television(TV)	32	Radio	14	23	67
PIGMENT	7.15	Color	51	Skin	24	15	Color	43	Skin	29	17	76
LICHENS	6.64	Like	11	Plant(s) Similar	8	36	Plant(s)	15	Bug(s)	12	29	29
JITNEY	6.62	Kidney	10	Car	5	48	Car	14	Jet Jittery	6	48	20
EFFORT	6.60	Try	28	Work	26	27	Try	37	Work	12	30	56
KEEPER	6.56	Zoo	25	Inn	9	26	Zoo	21	House Inn	12	27	58
PALLET	6.42	Mouth	27	Taste Throat	8	18	Mouth	20	Tongue	9	30	48
ORDEAL	6.17	Trial	11	Hard	5	39	Trial	21	Hard	8	37	40
YEOMAN	6.11	Sailor	11	Boat	9	39	Sailor	10	Boat Man	6	52	49
SEQUENCE	6.09	Order	28	Follow(s)	14	20	Order	15	Follow(s)	13	26	61
QUOTA	6.04	Number	18	Amount Enough	12	27	Amount	12	Enough Number	10	38	53

TABLE 4
(Continued)

Stimulus	Modality Stimulus $\underline{m}$	Aural					Visual					
		Primary	f_p	Secondary	f_s	N_1	Primary	f_p	Secondary	f_s	N_1	C
TARTAN	5.88	Tarzan	15	Plaid	9	40	Tarzan	14	Plaid	13	36	42
PALLOR	5.68	Pale	17	Color	14	35	Pale	32	Color	12	28	42
ENTRANT	5.66	Exit	23	Entrance	15	21	Entrance	19	Exit	18	29	60
BODICE	5.65	Dress	22	Body(ies)	18	20	Dress	18	Body(ies)	13	35	66
OVUM	5.48	Egg	17	Ovary(ies)	13	21	Egg	28	Ovary(ies)	13	32	58
XYLEM	5.47	Instrument	6	Music Phone Xylophone	5	51	Xylophone	15	Pholem Phone	6	46	35
TANKARD	5.34	Tank	18	Ale	8	33	Tank	19	Ship	10	29	46
NAPHTHA	5.34	Gas	13	Napkin	9	44	Gas	9	Soap	7	49	35
PERCEPT	5.29	See	14	Perceive Person	10	37	See	15	Perceive	10	37	46
RAMPART	5.27	Flag Rage Ramp(s) Song Wild	4	Battle Gun Ram Rampage Wall	3	51	Ramp(s)	8	Flag	5	41	32
ENDIVE	5.26	Swim	16	Food	6	39	Swim	13	Dive	11	49	42
VERTEX	5.26	Point	15	Angle	9	21	Angle Apex	10	Center	9	28	58
LOZENGE	5.24	Throat	53	Cough	4	22	Throat	52	Cough	9	23	66
MAELSTROM	5.22	Storm	16	Male(s)	11	40	Storm	23	Hail	4	54	27
ROMPIN	5.15	Romp	13	Round	12	42	Play	15	Romp	14	23	40
ROSTRUM	5.07	Speaker	15	Podium	9	28	Podium	15	Speaker	13	34	55
ARGON	4.96	Gas	21	Forest	9	32	Gas	18	Laboratory	6	50	38
FEMUR	4.87	Bone(s)	37	Leg	13	27	Bone(s)	35	Leg	12	27	64
NIMBUS	4.74	Clouds	31	Nimble	13	32	Cloud(s)	27	Nimble	13	38	49
STOMA	4.51	Stone	21	Stomach	9	40	Stomach	40	Plant Storm	5	33	32

TABLE 4
(Continued)

	Modality	Aural					Visual					
Stimulus	Stimulus $\underline{m}$	Primary	f_p	Secondary	f_s	N_1	Primary	f_p	Secondary	f_s	N_1	C
GRAPNEL	4.33	Grab	18	Gravel	10	42	Grape	14	Grapple Shrapnel	11	32	27
JETSAM	4.26	Jet	11	Flotsam	10	39	(Air)plane	22	Jet	17	30	49
DAVIT	4.25	Dab Paint	8	Davenport	6	52	David	17	Golf	6	42	17
CAROM	4.22	Game	12	Harem	10	36	Car	9	Game	6	44	27
BOOKIN	3.99	Body	27	Drink	12	42	Body	30	Book	4	45	39
ICON	3.95	Eye(s) Idol	8	Chemistry Economic(s) Element Science	3	56	Ion	13	Atom Idol	6	54	29
MATRIX	3.93	Math	20	Algebra	4	38	Math	8	Algebra Bone	6	46	40
GAMIN	3.90	Ray(s)	15	Game	9	52	Game	26	Play	4	49	27
WIDGIN	3.86	Wedge	22	Witch	11	45	Wagon	20	Window	6	37	20
CAPSTAN	3.85	Captain	13	Ship	8	38	Captain	45	Ship	14	31	33
LATUK	3.68	Lattice	7	Latex Laugh	6	48	Late Latex	6	Animal Latin Lazy	4	53	22
FLOTSAM	3.67	Flower	11	Jetsam	10	58	Boat	13	Float	12	37	24
TUMBRIL	3.66	Tumble	18	Tumbler	7	45	Tumble	18	Fall	11	32	38
RENNET	3.60	Rent	10	Run	5	47	Remnant	11	Rent	8	57	25
DELPIN	3.59	Delta	16	Dolphin Fish	13	42	Dolphin	51	Fish	15	21	36
TAROP	3.54	Tar	10	Tarp	7	52	Tarp	13	Troop	8	46	21
ATTAR	3.54	Guitar	13	Tar	6	61	Altar	31	Alter Attic	7	30	13
ULNA	3.48	All	13	Bone	11	44	Bone	14	Radius	9	57	27

TABLE 4
(Continued)

Stimulus	Modality Stimulus m	Aural Primary	f_p	Secondary	f_s	N_1	Visual Primary	f_p	Secondary	f_s	N_1	C
KNPOD	3.46	Coupon	16	Peas	10	37	Cupid	29	Pod Tripod	5	35	19
LEMUR	3.42	Lean	7	Animal Leader	5	50	Animal	12	Femur	6	51	26
KAYSEN	3.41	Case	7	Army Box	4	46	Kitchen	8	Case	5	64	20
FERRULE	3.41	King	18	Rolling Pharoah Ruler	12	33	Fertile	9	Ferry	4	59	8
BALAP	3.35	Ball	24	Burlap	8	40	Burlap	21	Sack	8	32	22
WELKIN	3.30	Welcome	22	Wealthy	6	42	Welcome	9	Walk	8	41	28
GOJEY	3.26	Go	10	Goat	7	60	Gooey	11	Golf	8	42	9
BRUGEN	3.23	Brute	16	Drink	7	39	Beer Brute	6	Germany	3	65	22
BYSSUS	3.21	Muscles	25	Bicep(s)	21	24	Abyss	7	Bus	5	64	10
QUIPSON	3.20	Quicksand Whip(s)	13	Sand	12	36	Joke	12	Quip	11	45	19
NARES	3.08	Nose(s)	10	Juarez None Town	3	55	Hair(s)	15	Nose(s)	12	32	19
SAGROLE	3.06	Sag	7	Bedroll	5	63	Sargeant	10	Sag	6	57	13
GOKEM	2.98	Go-Cart	17	Goat	10	39	Go	11	Gawk	6	59	18
VOLVAP	2.96	Ball Bat	7	Baseball	5	48	Volvo	7	Car	6	63	19
ZUMAP	2.87	Zoo	17	Animal(s)	16	38	Map	14	Zoom	9	45	26
NOSTAW	2.69	Nostril	14	Nose	11	47	Nose	15	Straw	10	33	27
POLEF	2.64	Polish	11	Poland	9	35	Golf	19	Pole	14	29	30
MEARDON	2.56	Mirror	31	Face Look	3	51	Meadow	13	Mirror	8	53	16
NEGLAN	2.50	Negligence	8	Negligee	7	40	Neglect	21	Negligent	7	45	32

actually ranged from 84 for KENNEL ($m = 7.50$) to 8 for FERRULE ($m = 3.41$). The product-moment correlation between C and m was .80.

The preceding analysis indicates that both m and mode of stimulus reception are likely to play a role in determining the portion of an *S*'s associative hierarchy that is sampled under a given set of conditions. Accordingly, if an investigator has chosen to work with learning materials whose m is lower than that of common nouns and he wishes his materials to reflect the existing associative hierarchies of his *Ss* (e.g., to study mediation), then the norms from which these hierarchies are to be inferred must have been collected using the same mode of stimulation as is to be used in the experiment for which the materials are being prepared.

The two modes of stimulus reception were compared further by considering two additional measures. One measure (N_1), is an index of the number of associations given only once to a given stimulus. It is a measure of the number of idiocyncratic associations. The second measure (f_p) refers to the frequency of the primary association. These measures were selected because they may be viewed as characterizing opposite ends of the distribution of associations. The values for f_p and N_1 are also shown in Table 4 for each of the 96 stimuli. Two facts become evident from an inspection of the f_p and N_1 values in Table 4: f_p and m are directly related while the relationship between N_1 and m is an inverse one. A correlational analysis confirmed the presence of these relationships. The produce-moment r between f_p and m was found to be .55 for Cond. A and .50 for Cond. V. The rs for N_1 and m were -.76 and -.52 for Cond. A and V, respectively. All these rs differ significantly from zero, $p < .05$. The difference in the magnitude of the rs for N_1 and m in Cond. A vs. V suggested the possible presence of a modality difference in the N_1 measure. Therefore, these conditions were compared explicitly. The mean N_1 for Cond. A was 33.10 while the mean for Cond. V was 34.51, the difference between these means is not a reliable one, $t(95) = 1.21$, $p > .10$. Also, and importantly, a graphical comparison of the functions relating f_p and N_1 to successive twelfths of the m dimension for Cond. A and Cond. V failed to reveal any trends toward interaction of these measures with modality.

Continuing the analysis of f_p and N_1, it is to be noted that, even after m is partialled-out, the values of f_p and N_1 for Cond. A are reliably ($p < .05$) correlated with those obtained in Cond. V, the partial rs being .75 and .49 for f_p and N_1, respectively. Also, the degree of relationship between modes, again partialling-out m, is stronger for f_p than N_1 ($z = 2.94$, $p < .01$).

Evidently, then, considering the correlational evidence as a whole, as the *m* of a stimulus increases the tendency for it to elicit a dominant association, the primary, also increases. And, as might be expected, there is a complementary tendency for N_1, reflecting idiocyncratic associations, to increase as *m* decreases. However, the properties of the distribution of associations in the two modes appear to be similar with agreement being greater at the "primary end" than at the "tail end" of the distribution. Furthermore, this agreement between modes is largely independent of *m*.

Next consideration was given to degree of overlap among associations along the *m* dimension. A convenient index of the degree of overlap is the one described by Marshall and Cofer (1963, pp. 416-417), the Index of Total Association (ITA). The ITA was defined, for the present purposes, as the total frequency of associations which were given to more than one stimulus divided by the total number of associations given. Thus, the ITA must range between 0.0 (no associative overlap) and 1.0 (complete overlap). The *m* dimension was divided into successive twelfths, resulting in 12 sets of 8 stimuli each, with each successive set having a higher mean *m*. The ITA was calculated for each set of stimuli in each modality. For example, in Cond. A for the set of stimuli with mean *m* of 5.18, the total number of associations given to more than one stimulus in the set was 66; to calculate ITA, 66 was divided by the total number of responses in the set (800). The ITA for each set of stimuli in each modality is presented in Table 5. Inspection of Table 5 suggests that associative overlap, within sets of eight stimuli as employed in the present analysis, is extremely small, that there is no appreciable difference in the ITA for Cond. A and Cond. V, and that there is little systematic relationship between ITA and *m* for either modality. The latter two conclusions were supported statistically: a test of the difference between the mean ITA for the 12 sets of stimuli in Cond. A and the same mean for Cond. V yielded a $t < 1$; the rank order correlations

TABLE 5

Index of Total Association Within Sets of Eight Stimuli in Each Modality

	Mean *m* Level												
	2.78	3.26	3.50	3.81	4.40	5.18	5.49	6.23	7.10	7.89	9.14	10.42	Overall Mean
Cond.A	.21	.18	.19	.22	.19	.08	.14	.27	.25	.26	.06	.27	.194
Cond.V	.18	.16	.19	.18	.18	.16	.15	.29	.26	.25	.11	.16	.189

between ITA and m were .27 and .00 for Cond. A and Cond. V, respectively, and neither of these is significantly different from zero ($t < 1$). Because of the low frequencies of associative overlap shown in the present analysis, calculation of ITA for the entire set of 96 stimuli, taken together, did not appear promising and was not carried out.

Obviously, other indices of associative overlap could be computed. The ITA, however, explicitly takes account of all responses which enter into an overlap relation, whereas some other measures of associative overlap do not (cf., Marshall and Cofer, 1963), and, therefore, the ITA would seem to be most useful. As pointed out by Marshall and Cofer, however, further research is needed to evaluate the ITA.

It seems pertinent, nevertheless, to explore, at least tentatively, one implication of the finding that overlap, what little there was, did not appear to vary as a function of m or modality. Namely, it seems likely that the degree of interitem associative interference in lists constructed from the present materials should not vary greatly as a function of m or mode. Moreover, the absolute level of such interference should be relatively low. Put another way, insofar as the associations obtained here are also the ones that Ss would be most likely to employ as mediating associations during the course of learning a list of paired associates consisting of dissyllables, the level of interference among mediators should be about the same whether the material is presented visually or aurally. Evidence consonant with this interpretation comes from the recent finding that the learning of paired dissyllables does not vary as a function of mode of presentation (Schulz and Hopkins, 1968a). Similarly, the suggestion is that the interaction between mode and m observed by Schulz and Kasschau (1965) for the learning of serial lists of dissyllables is unlikely to be attributable to variation in the sources of interitem interference discussed above.

Finally, the data were examined to determine the extent to which Ss' associations represented a form of "clang association" under the two modes of reception. Schulz and Thysell (1965) have shown that Ss tend to give associations beginning with the same first-letter as the first or second syllable of the stimulus dissyllable under conditions of continued association, also, that this tendency varies as a function of m. The questions being asked here may be stated as follows: (1) Does this tendency vary with modality? (2) Are the trends for this tendency in relation to m the same in free as opposed to continued association? A tabulation was made of the number of initial-letter coincidences between the first or second syllables of each dissyllable and the associations given to it. The number of cases of initial-letter coincidences for the highest, intermediate and lowest thirds of the m dimension were then converted to percentages based on the total number associations given to the 32 dissyllables representing the three respective m levels. These percentages are shown in Table 6 as a function of m level, modality and syllable.

It may be seen in Table 6 that the tendency for there to be initial-letter coincidence between the first syllable of the stimuli and the associations given to them is inversely related to m. The degree of initial-letter coincidence involving the first-syllable is greater in Cond. V than in Cond. A at all points on the m dimension, but most notably in the case of low-m stimuli ($z = 8.40$, $p < .01$). It is also apparent that associations beginning with the same first letter as the second syllable of the stimulus were given less frequently than associations related to the first syllable and that the tendency to give such associations was largely independent of m and mode of reception.

TABLE 6

Percentage of Responses Beginning With Same Letter as First or Second Syllable of Stimulus Dissyllable for Successive Thirds of m Dimension

		m Level			
		Low	Medium	High	Overall
1st Syllable	Cond. A	34.8	23.9	8.2	22.3
	Cond. V	45.0	26.8	9.6	27.1
2nd Syllable	Cond. A	6.4	5.3	5.7	5.8
	Cond. V	6.3	5.8	5.0	5.7

The most noteworthy feature of the preceding results is that they provide a potentially important clue as to why commonality among associations in Conds. A and V decreased as a function of m (cf., p. 31). Quite clearly, this divergence could have arisen as a result of the fact that the initial letter of a low-m dissyllable played a greater role in determining an *S*'s association in Cond. V than in Cond. A. Thus, the state of affairs is not unlike that observed in the investigation of the distinction between the nominal and functional stimulus in paired-associate performance where it is commonly found that a single-letter (usually the first letter) of the stimulus term serves as the functional cue (e.g., Postman and Greenbloom, 1967). It is necessary, of course, to assume in addition that *S*s are more likely to respond to the fractional components of a low-*m* visually received stimulus than is the case when that stimulus has been received aurally. However, since it is quite probable that the individual components of a visually received stimulus are considerably more salient than those of an aurally received one, this does not seem to be an implausible assumption.

The present finding that *S*s tend to make more responses beginning with the same letter as the first syllable of the stimulus at low *m* than at high *m*, agrees with the results reported by Schulz and Thysell (1965) for continued associations. However, Schulz and Thysell reported that, in the case of continued associations, *S*s' tendency to make responses beginning with the initial letter of the second syllable of the stimulus also depended on *m*. This result was not obtained in the present experiment. However, taken together, the results of these two studies suggest that phonetic cues are important in both discrete and continued association tasks but that the initial letter of the second syllable of the stimulus does not become important as a phonetic cue until after the first association. Since, in the present experiment, each *S* gave only one association to each stimulus, this hypothesis cannot be unequivocally evaluated from the data of this experiment.

Exp. VI: PA Recognition Learning and m (Hopkins and Schulz, 1969)

As was found in Exp. II, the "classic" outcome of studies of the effects of stimulus and response (designated S_1 and S_2, respectively) *m* on PA learning has been, with few exceptions, that not only is performance directly related to *m* of either S_1 or S_2, but that, in terms of the ratio of the respective mean square, the effects of variations in S_2 *m* are 2 to 3 times as great as those of comparable variations in S_1 *m* (cf., Underwood and Schulz, 1960; Goss and Nodine, 1965). An interpretation of this finding offered by Underwood and Schulz (1960) is that in terms of the two-phase conception of PA learning *S* must learn to recall the S_2 member in the response-learning phase, as well as to associate it with the S_1 member in the associative phase. Accordingly, S_2 *m* is a variable in both phases of PA learning, whereas S_1 *m* is a variable only in the associative phase and, hence, S_2 *m* could be expected to have the greater effect on overall performance.

Empirically, the implication of the foregoing interpretation seems clear; namely, the problem is an analytic one involving the separation of the effects of S_1 and S_2 *m* on the two phases. A fruitful first step in this analysis appeared to be the one of determining the relative contributions of S_1 and S_2 *m* to the associative phase, independently of their effects on the response-learning phase of PA learning.

Underwood and Schulz (1960, pp. 95-96) have hypothesized that, given minimal necessity for response learning, the effects of S_1 and S_2 m will be equal. This expectation has been confirmed in two previous studies (Horowitz, 1962; Cuddy and Arbuckle, 1967). Both of these studies employed an associative-matching task to minimize the need for response learning. However, when multiple-choice procedures were employed to eliminate response learning S_1 m has been found to be more effective than S_2 m (Cieutat, 1961; Epstein and Strieb, 1962) and vice versa (Martin, Cox and Boersma, 1965). The effect of S_2 m has also been found to be greater than that of S_1 when prior familiarization was used in an attempt to minimize response learning (Epstein, 1963). In short, previous attempts to determine the contributions of S_1 and S_2 m to performance in situations presumed to involve only the associative phase seem notably lacking in consistency.

Some of the inconsistencies noted above may have resulted from the fact that the methods employed to minimize the need for response learning failed to accomplish this objective. The latter seems clearly, as noted elsewhere (cf., Lovelace and Schulz, 1966; Cuddy and Arbuckle, 1967), to have been the case in the study by Martin et al., (1965). Without attempting to detail further for one or another of these studies the manner in which response learning could have been a factor, it will suffice to note that studies employing a matching technique (Horowitz, 1962; Cuddy and Arbuckle, 1967) are least likely to have been deficient in this respect. However, since test trials with the matching technique are unpaced, this technique may not be as sensitive to underlying differences in associative strength as seems desirable for a determination of m's effects on the associative phase. In addition, S is allowed to consider all pairs simultaneously while in the usual PA situation he must deal with one pair at a time. The latter requirement having the advantage that it reduces the likelihood that S will be able to employ a "process-of-elimination" in narrowing his choices for difficult items. Again, the sensitivity of the matching technique may be reduced. Accordingly, in developing the task to be employed in the present study, an attempt was made to preserve the qualities of the matching technique requisite for the elimination of the need for response learning while certain features of the standard PA procedure were likewise retained, namely, pacing S's performance and requiring Ss to respond to one pair at a time. The latter features were anticipated to enhance the likelihood that even small differences in associative strength would be detected. The present task which may be characterized as a PA-recognition (PAR) task will be described in detail in the next section of this report.

Aside from the matter of potential lack of sensitivity, previous studies employing matching procedures have not considered variations in m beyond a simple contrast of two conditions, one in which S_1 m is high and S_2 m is low and the other in which S_1 m is low and S_2 m is high. To gain a more complete and systematic picture of m's effects on the associative phase, the present study involved a parametric variation of S_1 and S_2 m at three levels (high, medium and low) factorially combined.

Though S's primary response was a binary decision (yes-no), ratings of his confidence in this decision were also obtained. These ratings were used to construct iso-mnemonic curves relating the effects of m to performance within the context of the theory of signal detection. There do not appear to be any reports published previously which have evaluated the effects of m in this context.

Finally, since S_1 and S_2 were received aurally, the present study may be seen as having direct relevance for the first objective of this project (cf., p. 2). Moreover, it will be recalled that mode of reception failed to be a significant source of variance in PA learning under "standard" conditions when S_1 vs S_2 m were varied; hence, in contrast to our preceding studies, a series of visual conditions parallelling the aural ones were not included in this study.

Method.--Three levels of S_1 m, low (L), medium (M), and high (H), were factorially combined with three levels of S_2 m (L, M, and H) to define the nine treatment conditions. Each condition will be designated by the S_1-S_2 m-combination in the list for that condition, e.g., Cond. L-L, Cond. L-M, and Cond. H-H. Each list consisted of 10 pairs of the dissyllables. All pairings were formed with the restriction that there be no obvious associative connection between the members of a pair. Eight random orders of each list were prepared, four for study trials and four for test trials, with the restriction that no S_1 member appeared in the same serial position in any two of these random orders.

Materials for a 10-pair practice list were selected from the dissyllables scaled by Cieutat (1963) and paired such that the L-L, H-L, L-H, M-M, and H-H combinations of S_1 and S_2 m were each represented by 2 pairings in a mixed list. To acquaint them with the PAR task, all Ss were given 2 study and 2 test trials on the practice list prior to learning the experimental list.

A total of 242 Ss were used. Groups of 3 to 15 Ss were assigned to a pre-randomized order of the treatment conditions, as they reported to the laboratory. Some Ss were randomly dropped from some of the groups so that there remained 11 males and 11 females in each condition; 41 Ss were dropped for this reason. It was arbitrarily decided to replace Ss in any condition who failed to respond to, or used the "don't know" rating category for, more than 20% of the test pairs. One S was dropped from each of the L-L, L-M, and M-H conditions for this reason.

In the PAR task an appropriate list of pairs was presented, one pair at a time, on study trials and S was instructed to try to associate the second member of each pair (S_2) with the first member (S_1) so that he would later be able to recognize each pair. On test trials half of the pairs were presented just as they had been on test trials (A-B pairs); the members of the other half of the pairs were re-paired randomly (A-X pairs). Study and test trials alternated and S was to recognize the correct and incorrect test pairings (associations). Recognition of one or the other member of each pair was not sufficient for a correct decision, since all pair members presented on test trials had also been presented on study trials.

The lists were presented aurally, via a taperecorder, to the groups of Ss. Each group was given 4 study and 4 test trials in alternating fashion. The Ss were each provided with a test booklet containing a series of 7-point rating scales, ranging from "absolutely certain the pair is correct" (+3), through "do not know whether the pair is correct or incorrect" (0), to "absolutely certain the pair is incorrect" (-3). The rating scales for each trial were contained on a single page, and each scale was labeled verbally. As each test pair was presented, S was to decide whether the test pair was the same as, or different from, one presented on study trials. He then indicated his decision and his confidence in that decision by placing a check mark in the appropriate box on the rating scale.

The intrapair interval (onset of S_1 to onset of S_2) was 1.0 sec., and the interpair interval (onset of S_1 to onset of succeeding S_1) was 3.0 sec. The intertrial interval was 2.0 sec., during which time the word "Study" or the word "Test" was presented to identify the upcoming trial. The average stimulus duration was 0.5 sec.

Results.--Considering the primary dependent variable, the number of correct decisions, the acquisition curves showed no clear evidence of interaction between treatment condition and trials, so these data may be summarized in terms of mean total number of correct decisions in the four test trials. The means and their standard deviations are presented in Table 7, where they are given separately for A-B and A-X pairs. It may be seen in Table 7 that performance increased as either S_1 or S_2 m increased, $F(2, 189) = 39.37$ and $F(2, 189) = 14.97$, respectively, $p < .001$ in each case. The interaction of these variables was not significant, $F(4, 189) = 2.17$, $p > .10$, indicating that the effects of S_1 m were not reliably different at different levels of S_2 m, and vice versa.

TABLE 7

Mean Total Numbers of Correct Decisions and Their Standard Deviations, for A-B and A-X Pairs, as a Function of S_1 and S_2 m

Pair-type A-B

		S_2 m			
S_1 m		High	Med	Low	Total
High	$\overline{X}$	18.30	18.30	17.43	18.03
	SD	1.76	1.36	2.63	2.00
Med	$\overline{X}$	16.66	16.34	15.21	16.09
	SD	3.00	2.70	2.52	2.78
Low	$\overline{X}$	16.53	14.12	14.44	15.05
	SD	2.76	3.00	2.58	2.94
Total	$\overline{X}$	17.18	16.27	15.71	16.39
	SD	2.65	2.97	2.84	2.87

Pair-type A-X

		S_2 m			
S_1 M		High	Med	Low	Total
High	$\overline{X}$	17.89	17.30	15.75	17.00
	SD	3.15	2.21	3.10	2.95
Med	$\overline{X}$	15.66	14.39	12.08	14.06
	SD	3.37	3.19	3.24	3.55
Low	$\overline{X}$	15.03	11.53	11.53	12.71
	SD	3.51	3.65	3.79	3.96
Total	$\overline{X}$	16.21	14.42	13.14	14.59
	SD	2.52	3.85	3.85	3.93

The result that performance and *m* are directly related, has, of course, been frequently obtained in the past. However, in stark contrast to many previous results, the mean differences associated with changes in S_1 *m* were greater than those for changes in S_2 *m*, for both pair types. To further quantify this comparison, the ratio of the mean square for S_1 to that for S_2 *m* was calculated. This ratio was 4.17 for A-B pairs, 2.01 for A-X pairs, and 2.63 for A-B and A-X pairs combined. This represents a complete reversal of the traditional finding.

As shown in Table 7, overall performance was better for A-B pairs than for A-X pairs, *F*(1, 189) = 57.06, $p < .001$, and S_2 *m* had more effect on performance for A-X pairs than for A-B pairs, *F*(2, 189) = 3.81, $p < .05$; although S_1 *m* tended to have a greater effect with A-X than with A-B pairs, this interaction did not reach acceptable levels of significance, *F*(2, 189) = 2.74, $.05 < p < .10$. It may be noted that the pattern of these interactions is consistent with the previous observation that the superiority of S_1 to S_2 *m* was greater with A-B than with A-X pairs.

The performance differences between A-B and A-X pairs suggests that there may have been a response bias operating in this task. This was further evidenced by the result of a calculation of the proportion of responses which were "Yes, that is a correct pairing." This proportion ranged from .51 for Cond. H-H and Cond. H-M to .58 for Conds. M-L and L-L. Since this proportion should have been .50, a slight bias is indicated. However, an analysis of recognition performance which eliminated the possible consequences of bias led to exactly the same conclusions concerning the effects of S_1 and S_2 *m* and their relative contributions to performance.

In this analysis the confidence ratings were used to construct iso-mnemonic curves. Using the method outlined in some detail by Pollack, Norman, and Galanter (1964) and by Murdock (1965), the probability of a particular confidence rating, conditionalized on whether the test pair was A-B or A-X, was determined for each condition. The probabilities were then cumulated, for each condition, from a rating of +3 to -3, yielding 6 pairs of conditional probabilities with the 7-point rating scale employed. The iso-mnemonic curve is the curve obtained by plotting the cumulative probability of rating j, given an A-B test pair, $Pr(R_j\text{:A-B})$, on the ordinate and $Pr(R_j\text{:A-X})$ on the abscissa of the unit square. The area under the iso-mnemonic curve may be taken as an unbiased measure of recognition performance (cf., Pollack, et. al., 1964). The measure varies from .50 (chance performance) to 1.00 (perfect performance). It may be noted that although these techniques arose from signal detection theory, they are, as here employed, non-parametric and do not require the assumptions of signal detection theory.

The data for all Ss within a condition were pooled to calculate the conditional probabilities which were plotted on normal coordinates; a straight line was drawn through the points by eye, and the area under the line determined by the trapezoidal rule. The probabilities were first considered for Trials 1 and 2 (T_{1-2}) and T_{3-4}, separately. In each condition, a straight line appeared to fit the points quite well, the slope of the iso-mnemonic curve was one, or nearly so, and the area under the curve increased with practice, i.e., from T_{1-2} to T_{3-4}.

In Table 8* the areas under the iso-mnemonic curves for T_{1-4} are presented for each condition. It may be seen in Table 8 that the effects of the independent variables on this measure of recognition performance were similar to their effects on mean total number of correct decisions. In particular, S_1 m was more effective than S_2 m, independent of S-biases.

TABLE 8

Areas Under the Iso-mnemonic Curves as a Function of S_1 and S_2 m

	S_2 m			
S_1 m	High	Med	Low	Overall
High	.818	.785	.669	.754
Med	.639	.592	.540	.568
Low	.618	.520	.520	.544
Overall	.680	.591	.559	.600

The confidence ratings were also evaluated by assigning the values 1 through 3 to the confidence categories (3 indicating absolute confidence) and calculating mean ratings for correct and for incorrect decisions for each condition. Confidence was quite high initially, but did increase with stage of practice, for incorrect as well as for correct decisions. When pooled over the nine treatment conditions, the mean confidence ratings for correct choices were 2.54, 2.66, 2.76, and 2.80 for Trials 1 to 4, respectively; the corresponding means for incorrect decisions were 2.09, 2.14, 2.19, and 2.25. The mean confidence over T_{1-4} is presented in Table 9 for each condition, with the means for correct and for incorrect decisions presented separately. The means for incorrect decisions were based on somewhat lower frequencies than those for correct decisions and, hence, are somewhat more variable. It may be seen in Table 9 that, as would be expected, confidence was somewhat lower for incorrect choices. However, the effects of S_1 and S_2 m on confidence in a decision were grossly the same for both correct and incorrect decisions; i.e., the effects of the independent variables on decision confidence appeared to be independent of the accuracy of that decision.

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* Since the data points represented in Tables 8 and 10 were based on different n's, the marginal statistics in those tables were obtained by pooling the data before calculating these entries rather than simply averaging the appropriate cell entries.

TABLE 9

Mean Confidence Ratings for Correct and for Incorrect Decisions as a Function of S_1 m and S_2 m

	Correct Decisions			Incorrect Decisions		
	S_2 m			S_2 m		
S_1 m	High	Med	Low	High	Med	Low
High	2.89	2.89	2.76	2.39	2.36	2.27
Med	2.85	2.72	2.53	2.41	2.21	2.13
Low	2.82	2.31	2.30	2.29	1.86	1.95

On the other hand, other descriptive statistics based on the confidence ratings were in accord with expectations. For example, the conditional probability that an item was incorrect on Trial n+1, given that it was correct on Trial n, $Pr(I_{n+1}:C_n)$, was calculated for each treatment condition, pooled over n = 1, 2, and 3, and with confidence on Trial n of 1, 2, or 3. Recalling that a rating of 3 indicates highest confidence, it may be seen in Table 10* that this proportion was inversely related to confidence on Trial n. This

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* Since the data points represented in Tables 8 and 10 were based on different n's, the marginal statistics in those tables were obtained by pooling the data before calculating these entries rather than simply averaging the appropriate cell entries.

TABLE 10

Conditional Probabilities that an Item was Incorrect on Trial n+1, Given That It was Correct on Trial n, $Pr(I_{n+1}:C_n)$, as a Function of S_1 *m* and S_2 *m* with Confidence on Trial n of 1, 2, or 3

S_1 *m*	Confidence on Trial n	High	Med	Low	Total
High	1	.13	.18	.32	
	2	.15	.14	.22	
	3	.04	.06	.08	
	1, 2, or 3	.05	.07	.12	.08
Med	1	.21	.29	.30	
	2	.22	.26	.34	
	3	.10	.12	.22	
	1, 2, or 3	.12	.16	.26	.17
Low	1	.37	.36	.42	
	2	.25	.37	.35	
	3	.11	.22	.24	
	1, 2, or 3	.14	.29	.31	.24
Total	1, 2, or 3	.10	.16	.22	.16

result is in complete agreement with the assumption that rated confidence is an indicant of degree of learning, and the expectation that there be fewer such shifts the higher the degree of learning. Hence, performance and confidence were related in the expected way. It may also be seen in Table 10, most clearly in the marginal statistics, that the relative effects of S_1 and S_2 *m* on $Pr(I_{n+1}:C_n)$ were similar to their effects on mean number correct and area under the iso-mnemonic curve. Though the differences here were small, the relative contribution of S_1 *m* was greater than that of S_2 *m*.

Discussion.--This research was initiated in an attempt to answer the following question: What are the effects of variation in S_1 versus S_2 *m* on the associative phase of PA learning? The answer, as inferred from PAR performance, is that performance in the associative phase is a direct function of S_1 and S_2 *m* with the effects of variations in S_1 *m* being greater than those of S_2 *m*. This result was reflected by mean total numbers of correct responses, areas under iso-mnemonic curves, and a measure of shift behavior

$Pr(I_{n+1}:C_n)$. A second question may now be posed: Are the inferences based on the results obtained with the PAR task under the present conditions to be regarded as definitive ones in the sense that they may be expected to have wide generality? The answer to this question seems to be yes, in some respects, and no in others.

On the affirmative side, it may be noted that the present results were obtained with parametric factorial variations through the full range of m values for both S_1 and S_2 m. The introduction of paced test trials and the requirement that Ss respond to one stimulus at a time can reasonably be assumed to have permitted a finer discrimination of differences in associative strength than had been accomplished with the associative-matching task. Also, as with associative matching, the need for response learning was probably effectively eliminated.

When one returns, albeit retrospectively in light of the obtained results, to a consideration of the PAR task and the use of aural presentation, there is at least the possibility that an unanticipated source of interference may have played a role in the present outcome. Moreover, this source of interference may be indigenous to certain aspects of the present procedures and, therefore, limit the generality of the obtained results considerably. The reasoning regarding this potential source of interference is as follows.

Assume that the recognition response (r) presumed to be elicited by S1 (r_{s1}) and S2 (r_{s2}), respectively, is a critical component of PA learning (cf., Goss, 1963; Goss and Nodine, 1965). Evidence supporting such an assumption has been obtained by Martin (1967a; 1967b) in his demonstrations that correct responding in PA learning was contingent upon the occurrence of a correct r_{s1}. Assume further that the latencies of r_{s1} (Lr_{s1}) and r_{s2} (Lr_{s2}) are inversely related to the m of S1 and S2. This assumption appears to be a plausible one in light of evidence from a variety of sources; namely, recognition thresholds have been shown to be higher for low than high m stimuli (Kristofferson, 1957), reading rate seems to be a direct function of m (Conrad, 1962) and search-time has been found to be lower for high than low m stimuli (Schulz and Lovelace, 1964). Finally, since aural presentation of S1 and S2 is necessarily successive, except in the special case of dichotic presentation, it may be assumed that the physical presentation of S2 may have interfered with the occurrence of r_{s1} since the S1-S2 interval was a very short one (1.0 sec.). The latter assumption when combined with those stated earlier leads to the expectation that the effects of S1 m will be greater than those of S2 m inasmuch as the S1-S2 interval may have been shorter than Lr_{s1} when S1 m was low but longer than Lr_{s1} when S1 m was high. Also, and importantly, the occurrence of r_{s2} is not subject to a similar

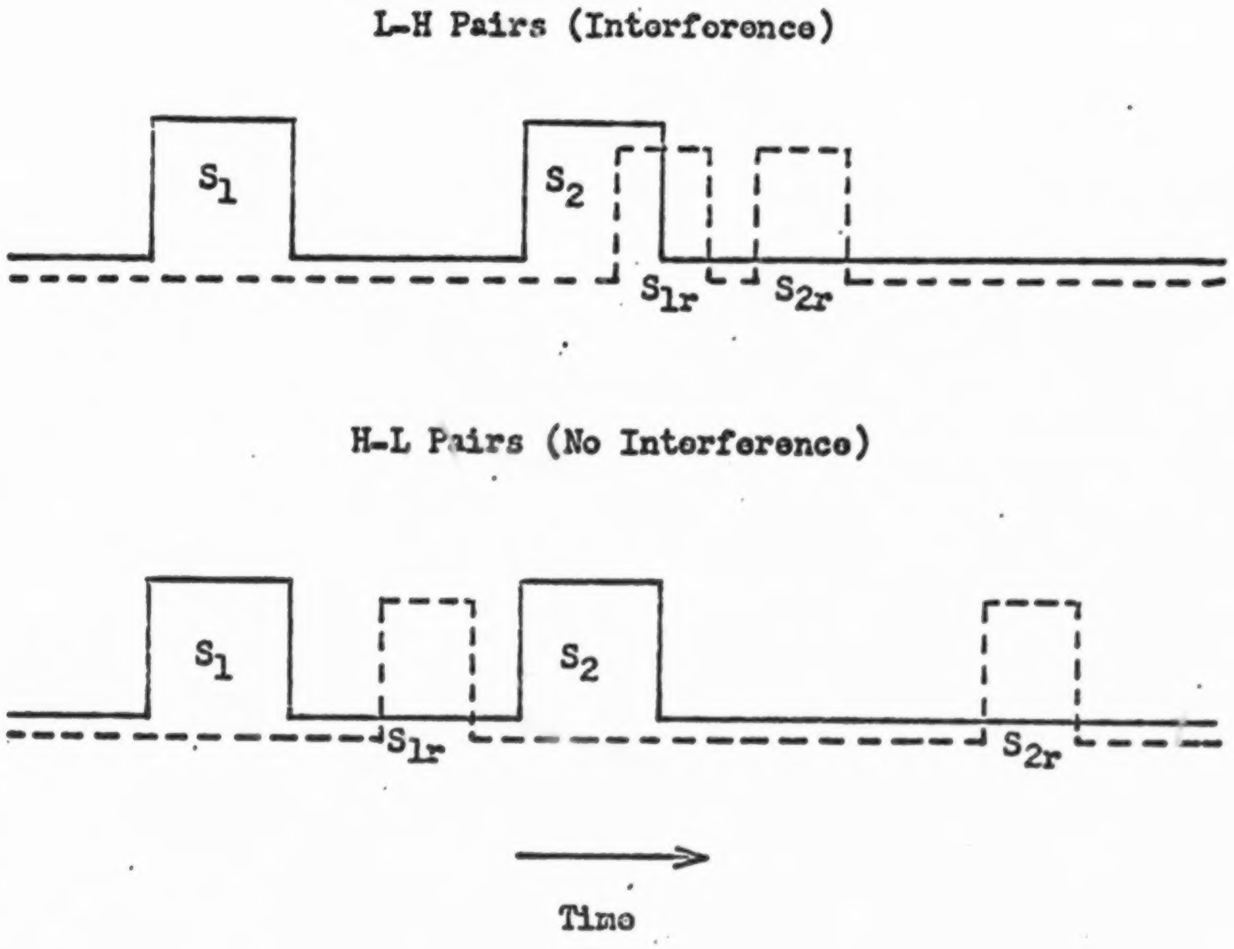
L-H Pairs (Interference)
S1
S2
S1r
S2r
H-L Pairs (No Interference)
S1
S2
S1r
S2r
Time

FIG. 6. Schematic representation of interference with the recognition response to S_1 (S_{1r}) under conditions of consecutive presentation of S_1 and S_2.

source of interference. Fig. 6 depicts the state of affairs for L-H and H-L in terms of the foregoing assumptions. In short, the "interference hypothesis" predicts a greater effect due to S_1 than S_2 m, even if the effects of m qua m had been symmetrical for S_1 and S_2.

Though the preceding analysis of the PAR task is based on numerous assumptions, this analysis is readily amenable to direct empirical scrutiny. For example, variation of the length of the S_1-S_2 interval should be informative, particularly so, if the simultaneous case (under visual conditions) were to be included.

Hopkins (1967) performed an experiment designed to evaluate further the merits of the "interference hypothesis" and to determine, among other things, whether the effects of m on PAR learning under visual conditions are similar to those observed here under aural conditions.* Using materials and procedures parallelling closely those employed in the present experiment, he compared the effects of variations in S_1 vs. S_2 m when PAR learning involved simultaneous as opposed to successive presentation of pair members. The expectation was that simultaneous presentation of S_1 and S_2 would minimize, if not eliminate, interference of the type that had been postulated to occur with successive presentation. Accordingly, the effects on PAR performance of S_1 and S_2 m under simultaneous conditions should be approximately equal in magnitude. Under successive conditions, even if reception is visual, interference would be anticipated to be present and S_1 m should have a greater effect on performance than S_2 m. The trends in Hopkin's data were, in general, in accord with these expectations. This was true both for number of correct choices on test trials and for the latencies of the choices. However, the reliability of these trends from the standpoint of statistical significance was questionable in some instances. Therefore, additional research will be required to establish firmly the teneability of the "interference hypothesis."

In conclusion, two additional matters would seem to merit comment. First, though the conclusion that the effects of S_1 and S_2 m on the associative phase of PA learning are asymmetrical must remain tentative pending the outcome of further research, it should be noted, nevertheless, that such a finding is not difficult to accommodate theoretically in the context of the operations defining *m*, Underwood and Schulz's (1960) expectation of symmetrical effects notwithstanding. Namely, S_1 being the initiating stimulus for the elicitation of its associates, the higher its *m*, the greater will be the variety and/or strength of a single dominant associate among the associates that S_1 elicits. Hence, the greater the likelihood that one or more of these associates and/or S_1 itself (depending on its *m*) can be and/or have been associatively related with S_2 directly. That is, it may be the relationship of S_1, or its associates, with S_2, per se, that is critical for *m*'s effect on the associative phase rather than the relations between the associates of S_1 and S_2 as assumed by the associative-probability theory of Underwood and Schulz (1960).

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* Since the study by Hopkins was part of his doctoral research, it included a concern with several problems which are only tangentially related to the objectives of the present project. Therefore, it would take us too far afield to consider all aspects of this study here. Anyone interested in the details of this study may obtain a copy of the dissertation from University Microfilms.

Second, the results of the present study suggest that methods derived from the theory of signal detection can be productively and meaningfully applied to the analysis of *m*'s effects on PAR performance. Hence, it may be equally productive to extend the use of these methods to the analysis of the effects of other material and task variables in the PAR situation.

General Discussion of m and Mode

Most of the task situations commonly employed in verbal-learning research have now been examined to assess the role of presentation mode when duration of stimulation in the two modalities was the same and the *m* of the material being presented varied from low to high. The results, considered across tasks, seem reasonably conclusive in the following regards: (a) The effect of modality, when present, was not a simple "main effect;" rather, mode tended to be a variable by virtue of its interaction with *m* and the type of task. (b) Overall performance remained largely unaffected, provided the material being learned was at the high end of the *m* dimension, though trends favored aural over visual presentation in three of four tasks. (c) If presentation mode had an effect, this effect was most apparent with low-*m* material and, in terms of performance, visual was superior to aural presentation. In the case of word associations, there was less commonality between associates to aurally vs. visually received verbal stimuli and the tendency for associations to begin with the same first letter ("clang associations") as the stimulus was greater under aural than visual conditions. (d) The sex of the *S*s and mode of presentation did not interact, with the possible exception of verbal-discrimination learning where males favored visual and females favored aural presentation.

From an interpretative standpoint, it had been thought that the present experiments might shed some light on the effect of mode relative to the two phases of learning, the associative- and response-learning phases. The facts are as follows: (a) Mode and R-term m did not interact in PA learning; yet, response-learning is known (cf. Underwood and Schulz, 1960) to be a prominent factor in performance under these conditions. (b) Overall performance in free learning, the analogue of response learning, failed to reflect a nonadditive effect due to mode and m. (c) Even though the necessity for response learning was at a minimum in the verbal discrimination situation, mode and m, nevertheless, interacted. Though one might be tempted to conclude from the foregoing that an effect of mode, when present, is on associative rather than the response-learning phase, such a conclusion would be at variance with the fact that S-term m, whose affect is presumed to be primarily on the associative phase, also failed to interact with mode and the fact that mode and m had nonadditive effects on order of item output in free learning. In short, further research seems indicated. Moreover, it may be necessary to employ a more direct approach (e.g., tests for response availability during the course of acquisition or test trials not requiring recall) to determine whether or not, and when, mode is affecting one phase or the other or both.

In addition to further research on the phases of learning, the hypothesis that differences in aural vs. visual STM may be instrumental in the production of an effect due to mode in some situations clearly merits further investigation. A first step might be to define more precisely the meaning of "short" within the present types of task situations. Similarly, it may be productive to determine whether, indeed, the recall of visually received material is more susceptible to disruption from PI and RI than aurally received material as well as attempting to assess directly the manner in which mode affects rehearsal and/or S-term and R-term encoding. It will also become increasingly important to determine the extent to which the processes identified in one task situation can be shown to be operative in others as well. The identification of such trans-situational processes will facilitate the accomplishment of an optimally parsimonious theoretical account of the role of presentation mode in verbal learning.

Finally, it will be necessary to establish more unequivocally, in subsequent research, whether the finding that S_1 m had a greater effect than S_2 m in aural PAR learning is to be regarded as being modality related rather than being merely a function of whether S_1 and S_2 are presented successively. The evidence available now favors the latter interpretation.

Abstractness

The abstract-concrete dimension of verbal material as introduced in the twenties by Goldstein (1942, 1948) is a variable which is presumed to influence learning (Stoke, 1929; Jampolsky, 1950; Paivio, 1963), recognition memory (Gorman, 1961), visual recognition speed (Riegel and Riegel, 1961), and reading and spelling (Bloomer, 1961). Attempts have also been made to show that this dimension differentially affects the loss of vocabulary in aphasic patients (Siegel, 1959; Greenberg, 1963). However, as far as the writer is aware, the effects of this variable had not been investigated in relation to the mode of stimulus reception. Further, having been identified, as noted above, as a variable that affects reading and spelling; its investigation seemed particularly germane for potentially fruitful applications of the findings of this project in educational settings.

The abstractness, hereafter called A, of 329 nouns whose Thorndike-Lorge (1944) frequency was in the 50-100 per million range was scaled by Spreen and Schulz (1966). The m and pronounceability of these words were also scaled; thus, when A was varied the latter attributes were held constant.

The scaling of A was accomplished by having Ss rate the 329 words on seven-point scales (1 denoting most abstract and 7 least abstract) as to their specificity of reference and concreteness in terms of sense experience. Actually, specificity (s) and concreteness (c) were scaled separately by independent samples of Ss; however, it was necessary to ignore this distinction in selecting materials for the present studies otherwise it would not have been possible to hold m and pronounceability constant while varying A. In order to take advantage of the correlation ($r = 0.63$) between s and c, the mean ratings for a given word on the s and c scales were simply summed and this sum was taken to represent A for the present purposes. This permitted A values to range (potentially) from 2 to 14 since the values of s and c could range from 1 to 7. The high-A (abstract) lists in the present series of studies had an average A of (7.58) and the low-A (concrete) lists had an average A of (11.81),(hereafter designated simply as HA and LA, respectively). The inversion of the size of the means and what is being called high and low comes about because of the location of anchoring stimuli on the Spreen and Schulz s and c scales where a rating of 1 denoted abstract and a rating of 7 denoted concrete. Since the choice of locations for these anchoring stimuli was entirely arbitrary, this inversion is of no consequence. Therefore throughout the remainder of this report HA will mean abstract and LA less abstract, or concrete. Thus, a typical HA word was one such as faith and a typical LA word was one such as goat. The levels of m (8.28) and pronounceability (4.00) were the same for the HA and LA lists. The details of the scaling operations and the scale values for each word may be found in the paper by Spreen and Schulz. It may be noted also that a more extensive set of materials consisting of 925 nouns scaled for A has recently been made available by Paivio, Yuille, and Madigan (1968).

Exp. VII: Serial Learning and A

While A had been shown to effect PA learning (e.g., Paivio, 1963; 1965), we were not aware of any studies investigating its effects on serial learning. Nor, had A been studied in relation to mode of stimulus reception. Further, since mode and m interacted when S's task involved serial learning by the anticipation method (Cf., pp. 8-10), it was of interest to determine whether A would interact in a similar fashion. If it did, this might provide us with some additional clues as to a suitable theoretical interpretation of m's effect in relation to mode.

Method.--The basic design was a 2 x 2 factorial in which mode (aural or visual) and two levels of A (high or low) were the sources of treatment classification. Two 10-item HA and two 10-item LA lists were employed. To increase generality further, subgroups of Ss were presented the lists in three different serial orders.

The interitem and intertrial intervals (onset to onset) were 2 sec. A buzzer (aural conditions) or three number signs (###-visual condition) served as starting cues. All Ss learned by the method of serial anticipation. The learning session consisted of 16 anticipation trials. There were 96 Ss, 24 per condition.

Results.--Since the acquisition curves did not show evidence of systematic trends toward an interaction between trials and treatments, performance was measured in terms of the total number of correct responses for all 16 trials. The means of this measure were used to summarize and analyze the data. The variances of the various sub-groups were found to be homogeneous statistically, F max (5, 16) = 7.06, $p > .05$, thus permitting comparisons of the means via analysis of variance.

The results are summarized in Table 11 where the means and S.D.s for total numbers of correct responses are shown as a function of mode, A and S's sex. Considering first the combined means in Table 11, it can be seen that performance was an inverse function of A and that learning under aural conditions was superior to that under visual conditions of reception. Both of these trends in the data are statistically reliable ones, F (1, 80) = 8.90, $p < .01$ and 5.12, $p < .05$, for the main effects of mode and A, respectively. The remaining trends in the data, including the slight trend for the effect of A to have been greater under aural than visual conditions, fail to achieve satisfactory levels of statistical significance, $ps > .05$.

Possible effects of A on the shape of the serial-position curves were assessed by plotting the relative proportions of correct responses which occurred at each serial position under a given

TABLE 11

Means and SDs for Total Numbers of Correct Responses during 16 Trials of Serial Learning as a Function of Mode, *A* and *S*'s Sex

		A			
		High		Low	
Mode	*S*'s Sex	Mean	SD	Mean	SD
Visual	Male	109.50	12.18	103.25	13.89
	Female	87.08	19.31	104.25	23.25
	Combined	98.29	19.50	103.75	18.74
Aural	Male	103.00	21.51	118.08	22.44
	Female	110.00	16.24	118.50	15.76
	Combined	106.50	18.98	118.29	18.97

condition. No systematic differences in the shapes of the curves appeared to be present.

Rank order correlations for number of correct responses under visual vs. aural conditions were found to be .70 and .78 for the two respective lists of HA items and .48 and .66 for the two LA lists. Thus, correlations for LA items appear to be somewhat lower than those for HA items.

Discussion.--The present results may be contrasted with those obtained in our first experiment (Schulz and Kasschau, 1966) with *m*. First, both *m* and *A* were related to performance in serial learning, in the case of *m* the relationship is direct and in the case of *A* it is inverse. Second, while *m* and mode interacted, *A* and mode did not. It appears, therefore, that *m*'s interaction with mode cannot be attributed to covariation of *m* and *A* in Exp. I. On the other hand, since the present materials were all high *m* nouns, it remains to be determined whether or not a similar variation of *A* at a lower absolute level of *m* would produce comparable results. Also, it would be of interest to vary *m* with *A* held constant. However, since the range of *m* values in the present materials is somewhat restricted in that all of the words had the same T-L frequency, this experiment might now be done using, in place of the present materials, the larger pool of 925 nouns recently scaled, among other attributes, for *m* and *A* by Paivio, Yuille and Madigan (1968). The words in the latter sample represent a substantially wider range of T-L frequencies and, hence, a wider range of *m* values. If the mode by *m* interaction is obtained with *A* held constant, the tentative conclusion reached here that the effects of *m* and *A* in relation to mode of reception are independent would be on substantially firmer ground.

Finally, it is to be noted that the present results provide clear confirmation of three other findings obtained in Exp. I with regard to the role of mode of reception in serial learning. First, mode did not affect the shape of the serial-position curve in terms of the proportion of total number of correct responses distributed across positions. Second, with high m materials performance under aural conditions of reception is superior to that under visual conditions (significantly so, in the present instance). Third, the sex of the S's did not interact with mode,* nor was sex, as a main effect, a significant source of variance.

Exp. VIII: Paired-Associate Learning and A

In 1965 Paivio reported that stimulus- vs. response-term A in PA learning had rather profoundly different effects on PA performance than those obtained by varying m. That is, the variance attributable to changes in stimulus-term A was found to be eight times greater than the variance associated with comparable changes in response-term A. Additionally, evidence was obtained that one possible explanation for this finding is that concrete nouns have a greater capacity to evoke imagery than abstract nouns. Further, and of even greater interest in the present context, was the fact that Paivio's Ss had received the stimuli aurally. Since intuitively it seemed quite plausible that the likelihood that a noun will evoke imagery might also vary as a function of the mode of stimulus reception, the manipulation in the present experiment of A in the PA situation in conjunction with mode had added significance for our exploration of the role of input modality in verbal learning.

Method.--The design was a 2 x 2 x 2 factorial with mode (aural or visual), level of stimulus-term A (high or low) and level of response-term A (high or low) as the factors. The materials were exactly the same as those used in Exp. VII (serial learning). The 20 HA and 20 LA items of Exp. VII were used to construct the requisite HA-HA, LA-HA, HA-LA and LA-LA PA lists of the present experiment. To accommodate the necessary counterbalancing of items for stimulus- vs. response-term comparisons, there were eight basic lists, two for each combination of HA and LA, of 10 pairs. To enhance generality, there were two different pairings of the basic lists; hence, a total of 16 lists. Random orders of the items in each list were prepared, six for study trials and six for test trials.

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* Though trends suggesting such an interaction when A was high are present in Table 11, these trends cannot be regarded as statistically significant ones.

A total of 192 *S*s were used, 24 per condition. Study and test trials were alternated until *S* had received 12 of each. In all other details the procedure was identical to that employed in Exp. II (PA learning and *m*).

Results.--Inspection of the acquisition curves for the various conditions revealed them to be essentially parallel, hence, performance was analyzed, overall, in terms of mean total numbers of correct responses. The means and S.D.s for this measure are given in Table 12 as a function of conditions. Statistically, the only differences among these means which may be regarded as reliable ones are those attributable to modality, F (1, 176) = 4.89, $p < .05$), and sex, F (1, 176) = 8.89, $p < .01$). Performance under visual conditions ($\bar{X}$ = 72.09) exceeded that under aural conditions ($\bar{X}$ = 64.38) and males ($\bar{X}$ = 63.03) were inferior to females ($\bar{X}$ = 73.44). Trendwise, for both stimulus and response *A*, LA conditions led to better performance than HA conditions and, in the case of response *A*, this trend was marginally significant, F (1, 176) = 3.71, $p < .10$. Further, as may be seen in Table 12, the effects of response-term *A* were more prominent under aural than visual conditions of reception, F (1, 176) = 2.94, $p < .10$. The remaining potential sources of variance did not even approach statistical significance.

TABLE 12

Means and SDs for Total Numbers of Correct Responses during 12 Trials of PA Learning as a Function of Mode, Stimulus-Term *A*, Response-Term *A* and *S*'s Sex

		Number of Correct Responses Stimulus and Response *A*							
		H-H		L-H		H-L		L-L	
Mode	*S*'s Sex	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Visual	Male	65.25	32.49	72.83	29.62	57.50	24.15	69.00	23.54
	Female	70.92	24.18	77.92	18.16	87.50	17.48	75.83	11.70
	Combined	68.08	28.16	75.38	24.16	72.50	25.69	72.42	18.51
Aural	Male	56.58	24.47	50.84	26.80	66.50	30.00	65.75	21.91
	Female	57.25	27.19	67.42	18.80	74.16	22.99	76.50	24.73
	Combined	56.92	25.30	59.12	24.18	70.33	26.43	71.12	23.51

Discussion.--The most surprising feature of the present results is that *A* had little effect on performance and, what little effect it might have had, was in a direction contrary to that which has been observed typically (cf., Paivio, 1969). Though Paivio's earlier studies involved only aurally presented materials, he has subsequently, after the present experiment had been completed, shown that mode of reception seemed not to have been a variable in his studies of the effects of A. He has not, to our knowledge however, compared the effects of mode with duration of stimulation explicitly equated. Nevertheless, it is not at all obvious as to why the results of this study fail to agree with those obtained by him. A determination of the basis for the lack of agreement must await further research. When this research is undertaken it will also be of interest to assess further the reliability of the trend observed here for the effects of response-term A to be greater under aural than visual conditions. However, until this trend is shown to be a reproduceable one, it is probably unwise to speculate as to its significance with respect to the possibility that the imagery aroused under aural conditions differs from that obtaining under visual conditions. Also to be noted is the fact that A tended to affect serial learning more under aural than visual conditions, though as is the case here this trend was not a significant one statistically.

Equally perplexing is the finding here that performance under visual conditions exceeded that under aural conditions, whereas in all our previous experiments with high m materials the reverse has been true, at least trendwise. Again, taken in isolation without corroboration by additional research, it is unclear as to what significance, if any, is to be attached to this finding.

Exp. IX: Free-Recall Learning and A

In light of the fact that the results of Exp. III (Free-recall learning and m) had been reasonably productive, at least at a fine grain level of analysis, in revealing some potentially important differences in the way in which mode of stimulus reception may affect performance in this situation, the present study was designed to parallel Exp. III except, of course, that A rather than m was varied. Also, in terms of the two-phase conception discussed previously, the present experiment permitted further assessment of the role of mode of reception in the response-learning phase.

Method.--Since in all but a few respects the design of this study and the procedures employed in it were identical to those of Exp. III (Cf., p. 16), only the differences between the two experiments will be noted here. First, while m was varied "within lists" in Exp. III, A was varied "between lists." Thus, the design employed eight independent groups of Ss, 20 Ss per group (a total of 160 Ss) with A (high or low), mode (aural or visual) and rate of presentation (1 sec. or 2 sec.) as factorially arranged sources of treatment classification. Second, the list length was 20 instead of 12 items. The 20 HA and 20 LA items used in Exps. VII and VIII were again employed. It will be recalled they are equated for m and PR. Five random orders of each list were prepared. Third, and finally, Ss were given 10 alternated study and test trials in all conditions. Only 6 such sequences were used in Exp. III.

Results.--In addition to paralleling Exp. III with respect to design and procedures, the analysis of the data (Cf., pp. 16-22) was also conducted, insofar as possible, in a parallel fashion.* Considering first performance, overall, which is summarized in Table 13, several trends are apparent. First, as was to be expected, performance at a 2 sec. rate of presentation was superior in all conditions to that at a 1 sec. rate, F (1, 144) = 49.32, $p < .01$. Second, performance under LA conditions was generally better than under HA conditions, particularly when the rate of presentation was 2 sec. The latter trend toward interaction was only marginally reliable, F (1, 144) = 3.28, $p < .10$, while the main effect of A, low ($\bar{X}$ = 110.81) vs. high ($\bar{X}$ = 105.22), was a significant one, F (1, 144) = 6.70, $p < .05$. Third, mode was not a significant source of variance, indeed, the overall means were almost identical, visual ($\bar{X}$ = 108.98) and aural ($\bar{X}$ = 107.06). Fourth, the performance of females ($\bar{X}$ = 114.09) exceeded that of the males ($\bar{X}$ = 101.09) by a considerable and reliable margin, F (1, 144) = 31.60, $p < .01$. None of the remaining sources of variance approached significance.

As in the case of Exp. III, attention was turned next to a "finer-grain analysis."** Considered first was an item's input-position on study trials and the proportion of the time it was correct on test trials. This analysis of performance as a function of input-position failed to reveal any clear differential trends that could be attributed to the various treatments. Similarly, differences in the tendency to initiate recall with items from Input-Positions 18, 19 or 20 varied only slightly across conditions. However, at both rates of presentation Ss under HA conditions initiated recall slightly more often with these items under visual conditions (57.00% of the time) than under aural conditions (54.25% of the time) while the reverse was true under LA conditions, recall was initiated with these items more often under aural (50.50%) than visual (44.25%) conditions. Thus, a slight differential recency effect appeared to have been present.

A Tau Analysis (Cf., p. 18 and 20) designed to determine the

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* Certain analyses intrinsic to the use of a "within-lists" design used in Exp. III could not, for obvious reasons, be performed here because A was defined "between-lists."

** Since S's sex as a variable had not interacted reliably with any other variable, this variable was not considered in the remaining analyses.

TABLE 13

Means and SDs for Total Numbers of Correct Responses
during 10 Trials of Free-Recall Learning as a
Function of Mode, A, Rate of Presentation and S's Sex

A Mode of Presentation			High				Low			
			Aural		Visual		Aural		Visual	
N	Presentation rate (sec)	S's Sex	Mean	SD	Mean	SD	Mean	SD	Mean	SD
10	1	Males	91.50	9.08	96.70	10.68	93.10	11.04	95.70	15.46
10	1	Females	101.50	16.47	108.70	15.09	107.50	12.15	108.80	14.57
20	1	Combined	96.50	13.92	102.70	14.14	100.30	13.50	102.25	16.09
10	2	Males	107.80	16.10	104.20	15.08	117.10	15.14	109.50	14.29
10	2	Females	112.90	9.98	118.50	8.25	125.10	16.84	129.70	13.98
20	2	Combined	110.35	13.30	111.35	13.92	121.10	16.12	119.60	17.22

effects of the present treatments on the relationship *between* input and output was performed next. The degree of correspondence between input and output item order decreased with trials in all conditions with the sharpest decrease taking place over the first three trials. The average value of Tau, all conditions combined, was 0.17 on Trial 1 and -0.21 on Trial 10. Of greater interest was the finding that the average degree of correspondence was significantly higher under visual than aural conditions, F (1, 152) = 6.08, $p < .05$. In addition, rate of presentation and *A* interacted, F (1, 152) = 5.68, $p < .05$, such that at the 1-sec. rate degree of correspondence and *A* were directly related, higher correspondence under HA conditions, while at the 2-sec. rate the relationship was inverse, higher correspondence in LA conditions. The remaining sources of variance were non-significant.

The last of the "finer-grain analyses" involved an analysis of "priority" (Cf., p. 20-22). Correct responses and errors were considered separately. Table 14 contains the relevant data for correct responses. Shown there are the mean ranks above or below the median response for items correctly recalled in each condition throughout acquisition. The means in the columns designated "old" are based on items recalled at least once prior to the trial on which their rank was determined and the means in the columns headed "new" represent the ranks of items on the occasion of their being recalled correctly the first time. The only clear trend in the data is the one for "new" items to be given priority over "old" items in all conditions. This observation is supported statistically by the fact that the mean rank of "new" items was significantly higher than that of the "old" items, F (1, 152) = 14.86, $p < .01$. The remaining sources of variance were not reliable statistically.

TABLE 14

Mean Ranks of "Old" and "New" Correct Responses Above or Below the Median Response in Free-Recall Learning as a Function of Rate, Mode and *A*

		A			
		High		Low	
Mode of Presentation	Rate (sec.)	"Old"	"New"	"Old"	"New"
Aural	1	.09	3.53	.22	3.39
	2	.73	4.37	.80	4.02
Visual	1	1.08	3.98	-.17	1.48
	2	-.18	2.73	-.13	3.99

The analysis of errors revealed a significant trend for the mean rank of errors under aural to exceed that of errors under visual conditions, $\underline{F}$ (1, 152) = 7.82, $\underline{p} < .01$. This result seems, however, to have obtained mainly because almost twice as many errors occurred under aural as under visual conditions. Hence, the ranks of the errors in the aural conditions must almost inevitably have been higher than the ranks of the errors under visual conditions. Since this was the only significant source of variance, the priority of errors was not considered further.

The rank order correlation between performance under aural vs. visual conditions were somewhat higher under HA (0.60 and 0.57, 1-sec. and 2-sec. rate, respectively) than under LA (0.55 and 0.19, 1-sec. and 2-sec. rate, respectively) conditions. The correlations were also lower at the slower rate.

Discussion.--The finding that free-recall learning performance with LA materials exceeded that with HA materials is in agreement with similar findings recently reported by Paivio, Yuille and Rogers (1969). Similarly, Paivio and Csapo (1969) have also observed a trend for the effects of A to be greater at a slow rate than at a fast one, even though their materials, rates and procedures differed somewhat from the present ones. Furthermore, they regard this finding to be consistent with their interpretation of the effects of A in terms of the differential capability of HA and LA words for arousing mental imagery. However, and of greatest interest here, is the fact that neither mode and A nor mode and A and rate interacted. This suggests, according to Paivio's (1969) imagery-model, that the imagery evoking potential of HA and LA verbal stimuli does not seem to have varied as a function of the mode of stimulus reception under the present conditions.

One additional effect of A was discerned, namely, the degree of input-output correspondence, as indexed by Tau (Cf., p. 63), varied as a function of A. However, the nature of this function depended, in turn, on the rate of presentation. It was direct at a 1-sec. rate and inverse at a 2-sec. rate. Since this result does seem easily interpreted in terms of either Paivio's imagery model or a cumulative-rehearsal hypothesis, and since no clear primacy-recency effects due to A or rate were detected in the analysis of performance as a function of input position, it does not seem fruitful to speculate regarding possible interpretations of this finding. Rather, it will undoubtedly be more productive to conduct additional research designed to establish the significance, if any, of this finding.

Since the present experiment parallelled Exp. III in many respects, it is of interest to contrast the results of the two experiments by noting the similarities and differences in their outcome. To retain the proper perspective, it must be remembered, however, that there were several very important differences between the two studies: (1) The present materials, relative to those of Exp. III, were higher in *m*, regardless of whether *A* was high or low. (2) The lists of Exp. III contained 12 items while the ones used here contained 20. (3) While *A* was a "between-lists" variable, *m* was a "within-lists" variable. Considering gross performance first, mode of reception failed to effect free-recall learning in either instance. While *m* and rate interacted such that *m* had a greater effect at a 1- than a 2-sec. rate, in the case of *A*, it had a greater effect at a 2- than a 1-sec. rate, albeit only trendwise. This outcome is congruent with Paivio's argument (1969) that *m* and *A*, though correlated, have distinguishable effects on performance. Lastly, *S*'s sex was a variable here but not there.

At a more detailed level of analysis, both *m* and mode, had dramatic effects on performance as a function of input position in Exp. III, here very little effect was discernible due either to *A* or mode. In the case of the latter variable, this result is not as incompatible as it might at first seem since in Exp. III the effect of mode in relation to input-position was generally substantially less apparent with high- than low-*m* items.

With respect to degree of input-output correspondence, the *A* vs *m* comparison is complicated by the fact that the effects of *m* could not be determined in Exp. III because of the "within-lists" manipulation used there; nevertheless, at the 1-sec. rate, both here and there, the degree of correspondence was higher under visual than aural conditions and decreased with successive trials. As noted previously (Cf., p. 23) this result is consonant with the notion that verbal rehearsal may be more essential for visual than aurally received material because the former must be transferred to an auditory-storage system in memory while the latter is more likely to be stored in this system directly. In the present study, input-output correspondence was also higher under visual than aural conditions at a 2-sec. rate while degree of correspondence failed to differ in Exp. III at this rate. Until the effects of *m* are assessed at this rate little can be made of this difference in outcomes.

In terms of priority at recall, the only meaningful comparison (again due to the differences in the nature of the lists) is the one for "old" vs. "new" items, the two experiments agree in showing the latter to have priority over the former.

Exp. X: Short-Term Memory and *A*

The role of *A* in short-term memory (STM) under aural conditions of reception had not been investigated at the time this study was undertaken. Thus, in terms of the objectives of the present project, such a determination was clearly of empirical interest. It would, of course, have been of considerable additional interest, as had been done in most of our preceding studies, to compare STM under aural conditions with that under visual conditions. However, we were experiencing at this time technical difficulties with the special sound-operated relays which are essential for the equation of the durations of stimulation under aural and visual conditions. Hence, rather than have data-collection activity halt completely while awaiting the resolution of these technical difficulties, it was decided to use only aural conditions in this study.

Method.--The design was a 2 x 5 factorial with A (high or low) and retention interval (0, 4, 8, 16 and 48 sec.) as factors. A total of 200 Ss, 20 per group, was employed. The S's sex was not retained as a factor in the design. An S's sex was ignored in the assignment of Ss to conditions.

The materials were again the same as those used in the preceding studies of A, a 20-item list of LA and a 20-item list of HA items. Five different orders of each list were prepared.

To control rehearsal during the retention intervals, a modified version of Shepard and Teghtsoonian's (1961) number-recognition task was employed. Two-digit numbers between 0-99 were used. It was S's task to identify each number as an "old" number, one he had heard before during the experimental session, or as a "new" number , one he had not heard.

The word-recall and number-recognition tasks were combined in such a way that in S's view he was performaing a single memory task. That is, with a 2-sec. rate of presentation (onset to onset) throughout, all Ss were presented some numbers prior to presentation of the list of words, then in those conditions where there was a retention interval additional numbers were presented to fill the interval. The number of numbers presented prior to list presentation was arranged such that the total number of numbers identified was the same (24) for all Ss (e.g., Ss in the 4 sec. retention interval conditions had 22 numbers prior to list presentation and 2 during the retention interval while Ss in the 16 sec. retention interval conditions had 16 numbers prior to list presentation and 8 numbers in the retention interval). For all Ss, 50% were "new" and 50% were "old" numbers.

Presentation of the word, RECALL, was used to cue S's attempt to free-recall the words. The Ss, in groups of 4, were presented all stimuli via a taperecorder. The Ss wrote their responses (O or N in number-recognition and the words themselves in word-recall) on a suitably arranged data sheet. A period of 2 min. was allowed for free-recall of the words.

Results.--The percentages of items recalled correctly are depicted in Fig. 7 as a function of A and the length of the retention interval. Both A, F (1, 190) = 8.47, $p < .01$ and interval, F (4, 190) = 6.40, $p < .01$, were significant sources of variance. The interaction of interval and A was not. Thus, the generally superior performance under LA over HA conditions must be regarded as statistically independent of the length of the retention interval even though graphically it appears that some convergence obtains between the two curves in Fig. 7.

The possibility was entertained that Ss might, under the present conditions requiring written rather than oral recall, have had more difficulty in "translating" to their written forms the HA than the LA words. Hence, each S's recall protocol was re-scored giving him credit for any response that came reasonably close to representing the correct response word. Performance based on this lenient score under both HA and LA conditions was, of course, elevated; however, the shapes of the retention functions were not altered appreciably.

Analyses of the effects of input position on recall performance showed that, of the total number of items correctly recalled, proportionately more of them tended to come from the beginning (Positions 1-4) and end (Positions 17-20) of the list under HA than under LA conditions particularly so for retention intervals of 8 sec. or more. At 0 sec., there was essentially no difference as a function of A, and at 4 sec., only the primacy trend in the HA condition was apparent.

Since measures such as those used previously for analyses of input or output correspondence and priority tend to be relatively unstable when they are based on only a single recall trial, these analyses were not attempted here.

Discussion.--Because the overall effect of A on STM in this study did not appear to depend upon the length of the retention interval, no evidence for the interaction of these factors was obtained, the differences in recall were probably due simply to the fact that the LA items were learned to a higher degree than the HA items as indicated by the superiority of the LA over HA performance at 0 sec. A similar difference was present on Trial 1 of Exp. IX (A and free-recall learning) under aural conditions at a 2 sec. rate where the conditions were in most respects comparable to the present ones at a 0 sec. Further, when performance as a function of input position was examined in the present study, it was found, at the longer retention intervals, that proportionately more of the correctly recalled HA than LA items had occupied the initial and terminal positions in the input sequence. The items in these positions would be the strongest ones due to the effects of serial position on acquisition; hence, these items would also be the ones most likely to be retained over a

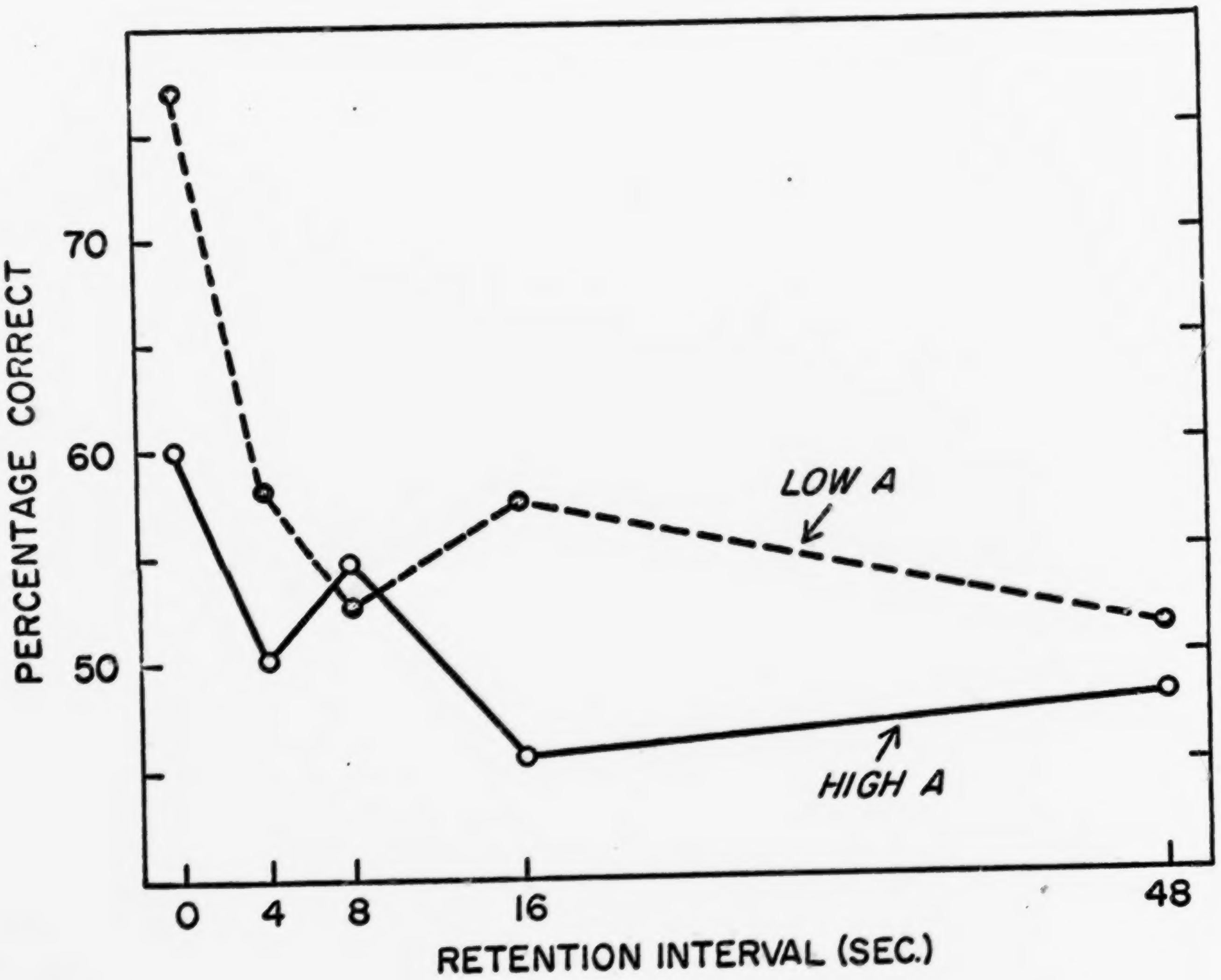

FIG. 7. Short-term memory as a function abstractness (A) and length of the retention interval.

retention interval. Under LA conditions where all of the items; including those in the middle of the input sequence, would presumably have been learned to a higher degree, a disproportionality as a function of input position would be expected to be less pronounced, as was indeed the case.

The results of the present study may now be compared with the ones recently reported by Borkowski and Eisner (1968). These investigators also investigated STM as a function of A with the same materials as those employed here. However, the material was presented visually, four or five words at once for 3 or 4 sec. on a memory drum. Each S studied and was tested successively on six sets of four or five words. Rehearsal was controlled with a counting task. In two experiments, Borkowski and Eisner failed to find an effect due to A either immediately (3 or 4 sec. retention interval) or after a delay of 18 or 20 sec. when Ss were recalling the first set presented to them. However, A did effect recall, better recall for LA than HA items, in subsequent cycles of one of the experiments. They concluded that the effect of A was contingent upon the presence of proactive inhibition (PI). Nevertheless, the results in the presence of PI and the procedural differences between their study and ours aside, it is important to note contrasting their "first-set" data with ours suggests the possibility that mode of reception and the effect of A might interact when recall is immediate and the materials are presented only once. This possibility is given further support by considering again Trial 1 performance in Exp. IX, this time under visual conditions at the 2-sec. rate, the respective LA and HA means were 6.50 and 6.80. In light of confirmation of the Borkowski and Eisner result by the data from Exp. IX, it seems as though it might be quite productive to repeat the present experiment with mode of reception as a variable.

General Discussion of A and Mode

This discussion can be brief since there does not seem to be much that needs to be said which has not already been said in the preceding discussions of the results of each of the four experiments reported in this section. Further, except for marginally reliable trends, the effects of mode and A were parallel ones; hence, it is not possible to utilize the presence of interaction as a clue in the identification of differences in the manner in which information received aurally may be stored and/or processed differently than when reception is visual. The most likely explanation for having failed to detect more convincingly these interactive trends is that the present materials simply did not permit us to vary A widely enough while at the same time holding m and Pr constant. Thus, while A was a statistically significant source of variance in three of the four experiments, the absolute magnitude of the differences in performance attributable to variation in A were nevertheless disappointingly small.

As noted earlier a more extensive set of materials has recently become available (Paivio, Yuille, and Madigan, 1968), it should be possible, therefore, to circumvent the limitations of the present studies by using these materials to construct lists whose _A_ differs more widely than it did here. Then, using the trends in the present data as a guide, it may be possible to delineate unequivocally the conditions under which mode and _A_ interact.

Intralist and Interlist Similarity

The exposition in this section will be facilitated by departing slightly from the format followed in the previous sections. A total of seven experiments involving manipulation of similarity and mode were conducted. Six of these are closely interrelated theoretically and methodologically involving manipulation of intralist similarity, the seventh has an altogether different focus in terms of both theory and method and is concerned with interlist similarity. Therefore, the latter experiment will be given separate consideration and the six interrelated experiments will be treated as a unit.

Exps. XI to XVI: Intralist Meaningful and Conceptual Similarity in Free-Recall and Paired-Associate Learning

Underwood, Ekstrand and Keppel (1965) have provided a comprehensive theoretical analysis of intralist similarity in relation to the process of verbal learning. They have identified a number of subprocesses which may be affected by the manipulation of intralist similarity. These subprocesses are as follows: (1) Response learning (2) S vs R differentiation (3) Interstimulus interference (4) Associative interference. The notion of distinguishing between response learning and associative phases has been discussed earlier at numerous points in this report. The term associative interference refers simply to interference in the latter of these phases. The degree of S vs R differentiation is posited to be contingent upon the degree to which the verbal units used as stimulus terms and those used as response terms in a paired-associate list are differentiable along some dimension of similarity e.g., when both are members of the same class of materials (nouns) differentiation is low, if different classes are involved (nouns vs trigrams) differentiation is high. Interstimulus interference is conceived of as being a function of any pre-experimental tendency among stimulus terms to elicit each other (e.g., synonymous adjectives). The implications of this analysis for the present research were seen as twofold: (1) The manipulation of intralist similarity permitted further assessment of the adequacy of the analysis. (2) The role, if any, of mode of stimulus presentation in relation to the manner in which similarity affects several of these subprocesses could be determined. Again, the latter determination was expected to be potentially useful in identifying possible differences in the manner in which Ss process aurally as opposed to visually received verbal stimuli.

The focus of Exps. XI to XIII was on meaningful similarity (synonymity) while Exps. XIV to XVI were concerned with conceptual similarity. The effects of these two types of similarity were determined separately for the response learning (free-recall learning) and associative phases (associative-matching task). Also, in the case of the latter separate determinations were made of the effects of similarity among stimulus-terms and among response-terms of a paired-associate list. Henceforth, the following abbreviations will be employed: free-recall learning (FRL), paired-associate learning with similarity among stimulus terms (PA-S), paired-associate learning with similarity among response terms (PA-R).

Several additional general considerations in the design of this series of experiments merit brief comment. First, since it has been found that intralist similarity tends to affect the two phases of learning differentially (e.g., Underwood, Runquist and Schulz, 1959), it seemed desirable for analytic purposes to ascertain the effect of this variable with tasks that permitted inferences regarding its effect on each phase separately. The FRL task was presumed to permit such inferences for the response-learning phase. However, a "standard" PA task involves both phases; therefore, the present PA task was modified to eliminate the need for response learning by having test trials consist of a matching task. Thus, Ss had available to them on test trials all the stimulus-terms and all the response-terms their job being to pair them correctly. It may also be noted in this connection that only one of our previous PA experiments (Hopkins, 1967) was designed to allow a comparison of the effects of mode of reception on the associative phase directly.

Second, taking a lead from Underwood et al., (1965), one of the four subprocesses, S vs R differentiation, was eliminated in our PA experiments by using different classes of verbal units for stimulus terms and for response terms. This it was hoped would simplify the interpretation of the data.

Third, by investigating the effects of both meaningful and conceptual similarity and contrasting their effects in PA-S, it was anticipated that inferences regarding the subprocess of interstimulus interference could be reached. Since words rated as highly synonymous were also found to be rated as having a high degree of associative connection between them (Haagen, 1949); interstimulus interference should be high among synonyms. At least higher than in the case of conceptual similarity where most of the words belonging to the same conceptual category do not usually have a strong tendency to elicit each other (Richardson, 1960). Thus, it should be possible to determine whether the subprocess of interstimulus interference varies as a function of mode of stimulus reception.

Fourth, by logic similar to that which was just employed in the case of interstimulus interference, the PA-R studies may be thought of as involving interresponse interference when, as was the case here, a PA-matching task is employed. The latter subprocess was not considered by Underwood et al because their analysis was designed to apply mainly to the "standard" PA situation.

Fifth, in the FRL studies, expectations opposite to those for interstimulus and interresponse interference would be held since the presence of interitem associative connection would be anticipated to facilitate performance on this task. Again, there is the further question, is this source of facilitation equally effective under both modes of stimulus presentation?

Finally, since Underwood et al., reported five experiments concerned with the effects of conceptual similarity, the results under visual conditions of certain of the present studies could be compared with their results.

Method.--The 10-item lists of words employed to vary meaningful similarity (high vs. low) had been used previously by Underwood, Runquist and Schulz (1959). The conceptually similar and dissimilar materials, 12-items of each variety, were taken from among those used by Underwood, Ekstrand and Keppel (1965). Specifically, their LS-HF and HS-HF lists were used. In the PA-S experiments, single letters served as response terms. The lists for the PA-R experiments were the "turned-over" versions of the PA-S lists. Ten different orders of each list were prepared for the FRL, PA-S and PA-R experiments. When meaningful similarity was varied the lists contained 10 items or pairs while those for variations in conceptual similarity contained 12 items or pairs.

In FRL studies, the interitem and intertrial intervals were the same as those used in our previous FRL studies (e.g., Exp. III). On test trials, Ss free recall was paced with a flashing light at a 2 sec. rate. The Ss responded orally, an E recording their responses. There were five alternated study and test trials.

The associative-matching task and the procedures in the PA-S and PA-R experiments parallelled exactly those described by Underwood, Ekstrand and Keppel (1965) for their Exp. IV except that all Ss received 5 rather than 2 alternated study and test trials.

The design of all experiments in this unit was the same in that a 2 x 2 x 2 factorial arrangement of treatments was employed with mode, similarity and S's sex as the bases for classification. A total of 240 Ss, 10 per cell in each experiment, were used to study meaningful similarity. In the case of conceptual similarity their were 14 males and 10 females in each group in each experiment, a total of 288 Ss.

Results.--Inspection of the acquisition curves for the various conditions indicated that the data could be summarized justifiably in terms of total numbers of correct responses for all five trials combined. While S's sex was a significant source of variance as a main effect for the PA-S and PA-R tasks for both types of intralist similarity with the performance of females exceeding that of males, it did not interact with mode or similarity in a statistically reliable fashion. In FRL, S's sex was associated with a statistically significant F (1, 72) = 4.39, $p < .05$, in only one instance. That F was the one for the interaction of mode, similarity and sex when meaningful similarity varied. The performance of males was unaffected by similarity while in the case of females performance increased under visual conditions and decreased under aural conditions as similarity increased. However, the magnitude of these increases and decreases in performance were very small. Further, since S's sex failed to interact with mode and similarity except in this one isolated instance, it seems unwarranted to regard this event as a theoretically significant one. In view of the general absence of interactions involving S's sex, the data for males and females were combined to permit a more economical summarization of the data.

The results of the present experiments are summarized in Table 15. The means, SDs and percentages (total number correct/total possible number correct) are presented there for the two types of similarity, two modes and three types of task.* The results for each type of similarity will be considered separately first. This will be followed by a comparison of the results for the two types of similarity.

Meaningful similarity failed to have its anticipated effect on FRL. As may be seen in Table 15, performance differed but little as a function of similarity. Statistically, the F for similarity was less than one. Mode also had very little effect though the slight trend toward better performance under visual than aural conditions achieved marginal significance, F (1, 72) = 3.20, $p < .10$. Mode and similarity did not interact.

In PA-S and PA-R, the expected effects of high similarity among stimulus or response terms are clearly apparent in that performance was poorer when similarity was high than when it was low, F (1, 72) = 5.46 and 13.79, $p < .05$ and $< .01$ for PA-S and PA-R, respectively. It is also to be noted that the effects of similarity appear to have been greater in PA-R than PA-S.** However, neither with PA-S nor with PA-R did mode and similarity interact, Fs < 1. On the other hand, and of potential interest, is the fact that while performance under visual conditions exceeded that under aural at both levels of similarity, the trends among the means in Table 15

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* Percentages are provided to facilitate the comparison of the results for meaningful with those for conceptual similarity since the former involved 10 while the latter involved 12 item lists.

** The within-groups error terms for PA-S (101.88) and PA-R (99.93) were very nearly the same; hence, this inference appears justified.

Table 15

Means, S.D.s and Percentages of Total Numbers
of Correct Responses During 5 Trials as a Function
of Type of Intralist Similarity, Mode of Presentation
and Type of Task

	Meaningful Similarity*											
	High						Low					
Mode	Aural			Visual			Aural			Visual		
Type of Task	$\bar{X}$	SD	%	$\bar{X}$	SD	%	$\bar{X}$	SD	%	$\bar{X}$	SD	%
FRL	29.75	4.83	59.5	33.05	4.06	66.1	30.95	4.56	61.9	31.15	4.26	62.3
PA-S	22.70	8.75	45.4	28.00	11.48	56.0	27.75	12.49	54.5	34.00	11.69	68.0
PA-R	18.95	8.99	37.9	22.20	9.56	44.4	27.45	12.83	54.9	30.30	12.17	60.6
	Conceptual Similarity**											
FRL	45.33	4.51	75.6	45.42	4.11	75.7	37.71	5.53	62.8	38.13	5.19	63.5
PA-S	38.25	11.59	63.7	36.75	13.46	61.2	45.38	12.50	76.2	36.71	13.88	61.2
PA-R	31.17	12.32	51.9	31.92	11.31	53.2	36.13	10.90	60.2	42.75	11.99	71.2

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* N = 20 per condition

** N = 24 per condition

suggest that the effect of mode was greater in PA-S than PA-R. Statistically, this trend was reflected by the fact that mode was a reliable source of variance in PA-S, _F_ (1, 72) = 7.13, $p < .01$, but not in PA-R, _F_ (1, 72) = 1.86, $p > .10$.*

Turning now to the results for conceptual similarity, it is apparent in Table 15 that this variable did facilitate FRL performance in the predicted manner, _F_ (1, 88) = 55.10, $p < .01$. Mode, on the other hand, was not a significant source of variance nor did it interact with similarity.

Though the trends among the means in Table 15 suggest similarity and mode interacted in the case of PA-S with the expected decrement due to increased similarity being present under aural but not visual conditions, the _F_ (1, 88) of 2.44 associated with the mode X similarity interaction cannot be regarded as statistically significant, $p > .10$. Nevertheless, the presence of this trend undoubtedly accounts for the fact that similarity, as a main effect, was also a nonsignificant source of variance. On the other hand, the tendency for performance under aural conditions to exceed that under visual conditions was significant, _F_ (1, 88) = 4.91, $p < .05$.

Curiously, the trends among the means in Table 15 for PA-R are completely reversed from those for PA-S with respect to the effects of mode and similarity. That is, mode had very little effect under high similarity conditions and under low similarity conditions performance under visual conditions exceeded that under aural conditions. Again, however, this interactive trend is not a significant one. But in this instance, it probably accounts for the fact that the main effect of mode was not significant, _F_ (1, 88) = 2.68, $p > .10$. However, in contrast to the PA-S results, similarity was a highly reliable source of variance, _F_ (1, 88) = 12.29, $p < .01$, and produced a decrement in performance under both aural and visual conditions. Further, if the possible mode X similarity interactions are ignored, the overall effect of similarity appears to have been greater with PA-R than PA-S.**

Finally, the results for meaningful similarity may be briefly contrasted with those for conceptual similarity. However, statistical comparison seems inadvisable since the studies of meaningful similarity were not conducted concurrently with those of conceptual similarity. Nevertheless, the agreement or lack of it in the significant trends for the two sets of data may be noted. First, mode and similarity failed to interact with either type of similarity in any of the three tasks. Second, mode was an effective variable only in the PA-S situation with both types of similarity. In the case of meaningful similarity, visual presentation was superior to aural but the reverse was true for conceptual similarity; thus, a mode by type of similarity interaction is implied. Third, considered overall, ignoring interactive trends, the effects of the two types of similarity were consistent across tasks; namely, increased similarity facilitated FRL and decremented PA-S and PA-R.

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* The within-groups error terms for PA-S (101.88) and PA-R (99.93) were very nearly the same; hence, this inference appears justified.

** PA-S within-groups variance (126.24) again highly similar to that for PA-R (121.73).

General Discussion.--Consideration of the present results within the context of Underwood, Ekstrand and Keppel's (1965) four-factor analysis of intralist similarity and results obtained under visual conditions by others reveals some agreements as well as some discrepancies both theoretically and empirically.

It was, for example, anticipated that meaningful similarity would facilitate FRL. Such facilitation was, however, confined to female Ss under visual conditions, and even there the effect was small (cf., p. 74). This finding is all the more surprising because conceptual similarity which apriori might be expected to have been less effective than meaningful similarity was actually more effective and consistently so for both sexes and modes (cf., p. 76). Further, using exactly the same materials as were used here, Underwood, Runquist and Schulz (1959) did find the expected facilitation in FRL due to meaningful similarity. The main difference between that study and the present one is that FRL was paced here and unpaced there. This may be an important difference. Namely, since synonyms tend to be associatively connected with one another (cf., p. 72), the introduction of pacing on test trials could have resulted in competition and interference as S attempted recall (i.e., several synonyms coming to mind simultaneously with only one being permitted to be recalled to each flash of the pacing light). Indeed, if this reasoning is correct, then the data also suggest that such interference is perhaps more prevalent under aural conditions of reception than under visual conditions since increases in meaningful similarity failed to facilitate the performance of both males and females under aural conditions. A final decision as to the merits of this interpretation must, of course, await additional research designed to assess it. Finally, if it were to be found that interitem associations can disrupt performance in FRL under paced conditions, then the analysis of Underwood et al. would require revision accordingly.

The results for conceptual similarity were fully in accord both with theoretical predictions and with the results obtained previously under visual conditions (e.g., Underwood et al., 1965). Further, since the results under aural conditions were parallel to those under visual conditions, the analysis of Underwood et al.

can be extended to the aural case, at least for this type of similarity and task situation.

Turning to the PA-S results, it will be recalled that increases in either meaningful or conceptual similarity would be anticipated to produce associative interference and decreased PA-S performance. This is the result that obtained, with one notable exception, under both aural and visual conditions. The exception was that an effect due to conceptual similarity did not obtain under visual conditions. Though no data seem to be available regarding the effects of conceptual similarity in the PA-S situation with a matching procedure on test trials, it is known that the predicted decrement occurs with "standard" anticipation procedures (Underwood, et al., 1965) using essentially the present materials. Moreover, since with the present materials (single letters as response terms) the matching and anticipation situations are not, in principle, as different as they might appear to be, the failure to obtain the expected results is all the more puzzling. Therefore, the possibility must be entertained that this result may have been due to an error of sampling.

On the other hand, it could be the case that the presence or absence of pacing on test trials plays a role, matching being unpaced while anticipation involves pacing. Thus, if these results could be reproduced, it could be inferred that the absence of pacing may reduce associative interference due to conceptual similarity under visual but not under aural conditions. However, since the mode X similarity interaction was not a statistically reliable one, additional study of this matter seems a necessary next step prior to further speculation along the present lines.

Inferences regarding the effects of mode in relation to interstimulus interference are also complicated by the ambiguity of the results for conceptual similarity under visual conditions. And, as was the case for associative interference, it may be best to await the outcome of further study before attempting such inferences. Nevertheless, if consideration is restricted to the results for meaningful similarity where there is not even the suggestion of a mode X similarity interaction, then it seems highly unlikely that the effects of this subprocess vary as a function of mode (cf., Table 15).

Finally with respect to the PA-S results, we are at a loss to explain at this time why performance under visual conditions exceeded that under aural conditions when the stimulus terms were adjectives but not when they were nouns.

The PA-R results were considerably less complicated than those for PA-S. The effects of meaningful and conceptual similarity were parallel throughout. In both cases there was a trend for performance under visual conditions to exceed that under aural conditions, increased similarity decreased performance and mode did not interact with similarity. Hence, the effects of what was termed earlier (cf., p. 72) interresponse interference do not appear to have been differential under the aural and visual modes of reception.

Lastly, it is interesting to note that, both in the case of meaningful and conceptual similarity, the variance attributable to the similarity manipulation among response terms was dramatically greater than the effects of comparable variations among stimulus terms even though the variability within-groups was roughly equal (cf., p. 74 and p. 76) when the present matching technique was employed. One implication of this result is that apparently Ss do not adopt a strategy of using the letters as stimuli and the words as responses regardless of the order in which the members of the pairs are presented on study trials (i.e., letter-word in PA-R and word-letter in PA-S). If they had done this, then the effects of similarity should have been the same in PA-S and PA-R. It remains, however, to be determined through further research just why it is that this differential effectiveness of similarity in PA-R vs. PA-S obtains. The present data do not provide any insight into this matter.

Exp. XVII: Interlist Acoustic Similarity in STM and LTM (Holborn, 1968)

This experiment was conducted as part of Holborn's doctoral research. A detailed report of this research may, therefore, be obtained from University Microfilms. It will suffice for the purposes of this report to include the summary of the report which Holborn prepared.

Holborn states, "The present experiment had four basic objectives: (1) to assess amount of PI as a function of acoustic similarity (AcS) and modality (Mo); (2) to examine possible increases in PI over time; (3) to determine the effects of repeated measurements (stage of practice, cycle of testing) on retention; and, most importantly, (4) to compare short-term (STM) and long-term (LTM) memory under common learning and retention procedures.

Sixteen independent experimental groups of 32 Ss each were included in a 2 x 2 x 4 x 2 factorial design. Between-Ss variables were Mo (aural vs. visual presentation), AcS (high vs. low), retention interval (0, 8, 24, 360 sec.), while cycle of testing (Cycle 1 vs. Cycle 3) was the sole within-Ss variable.* Acoustic similarity was manipulated between the stimulus terms of two PA lists conforming in the case of high AcS to the A-B, A'-C paradigm, and in the case of low AcS to the A-B, C-D paradigm. A common second (A-B) list was employed for the two paradigms. The 0-sec. retention interval was used for degree of learning estimations, while 8 and 24 sec. corresponded to STM intervals, and 360 sec. to an LTM interval. Eight independent rest-control groups (N = 16 apiece) were also employed, one at each of the four retention intervals for the two modalities. A number recognition task (Shepard and Teghtsoonian, 1961) filled all retention intervals exceeding 0 sec. Paralleling Goggin's (1966) procedure, experimental Ss were given single exposures of four-pair lists and were tested on the last two pairs of each list, which should have been subject to PI from the first two pairs. Thus, the first two pairs in each four-pair list defined List 1 (A'-C or C-D pairs), and the second two pairs defined List 2 (A-B pairs). Rest-control Ss learned a single two-pair list, equivalent to List 2 of experimental groups. The second pair was always tested before the first pair of List 2 for both experimental and control Ss. Scores from experimental and control lists were derived in three ways: (1) for number correct on the two pairs, an S's score being 0, 1, or 2 (AB scores); (2) for number correct on the last pair (first pair tested) in each two-pair list (A scores); and (3) for number correct on the first pair (second pair tested) in each two-pair list (B scores). An S's score could be 0 or 1 for both A and B scores. Interpretation of differences in results for A (three PI pairs) and B (two PI pairs, one RI pair) components of the total AB score focused primarily on the nonspecific RI present for B but not for A scores.

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* The longest of these intervals (360 sec.) may be regarded as involving LTM while the intervening intervals (8 and 24 sec.) involve STM (cf., Melton, 1963).

Acoustic similarity affected retention (high inferior to low AcS) but not learning for AB scores. Upon further analysis, however, the retention effect was found to be confined to B scores, suggesting augmentation of the AcS PI effect by nonspecific RI. For AB scores, Mo was a very powerful learning effect (aural superior to visual presentation) while it was ineffective in retention. However, the AB retention results were especially misleading since Mo interacted with score such that aural was superior to visual performance with A scores, while the reverse was true of B scores. The inference made was that recall with visual input was more susceptible to PI and recall with aural input was more susceptible to RI.

No increases in PI from 8 to 24 sec. were observed. Although Cycle-1 was superior to Cycle-3 recall, indicating the presence of cumulative PI in the latter cycle, there was no supportive evidence for Keppel's (1965) hypothesis that cumulative PI might obscure the effects of independent variables. Also the cycle x retention interval interaction of Goggin's (1966) experiment using the same number of test-cycles (three) was not evident in the present data. Finally, no divergence of STM and LTM results was indicated when learning and retention procedures were common for the two types of memory, and therefore Baddeley and Dale's (1966) hypothesis that AcS affects

STM but not LTM failed to be accepted (1968, pp. 76-78)."

General Discussion.--Several of Holborn's findings merit consideration in relation to the results obtained in our other experiments.

First, the results of Exp. IV (see p. 28) had led us to suggest the possibility that STM for aurally and visually received material may be differentially sensitive to RI and PI. Further evidence that this may be the case was obtained here. Hence, this matter will surely merit additional attention in subsequent investigation of the effects of input modality.

Second, the finding in this study with short PA lists (2 items) that performance under aural (73.5% correct recall) exceeded that under visual (54.5% correct recall) conditions when the test for retention was immediate (0 sec.) accords with a similar result obtained recently by Murdock (1967). Based on evidence obtained in a subsequent experiment, Murdock (1968) interprets this result to be attributable differences in the storage mechanism for aural as opposed to visually received inputs. The results of Exp. III had suggested this to be the case as well.

Third, since to our knowledge the effects of input modality in relation to AcS and STM vs. LTM have not been investigated previously, and since Holborn's summary does not include this interesting datum, it may be noted here that subsequent studies of the present kind could profitably explore retention in the region of 24 sec. That is, intervals of, say 18, 24, 30 and 36 sec. etc., might be employed. The reason for making this suggestion is as follows. A simple tabulation was made of whether aural or visual performance at retention intervals of 8, 24 and 360 sec. was superior for each condition, A score and B score and cycles all considered separately.* What emerges from this tabulation is that all but two of the nine reversals in trend for aural or visual superiority in recall occurred at that interval. Put another way, the trends for A scores in all conditions, and with two exceptions already noted, at all intervals were for performance under aural conditions to exceed that under visual. At 24 sec., the reverse of this trend obtained in four of the five comparisons at this interval. For B scores, retention under visual conditions was superior to that under aural conditions in all comparisons, except in the case of three of five comparisons at 24 sec. where the reverse trend again obtained.

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* Only the direction of the difference was taken into account. This was done because the data are probably too variable to make sensible comparisons of magnitude on a point by point basis when A scores, B scores and Cycles are considered separately.

Though we do not have a hypothesis as to what might cause this curious state of affairs to obtain, it seems highly improbable that seven of ten independent comparisons across a variety of conditions would show this reversal phenomenon purely by chance.

Finally, it seems clear that, in addition to attempting to replicate the present findings, it may be fruitful to study the effects of other forms of interlist similarity such as meaningful or conceptual similarity in the context of the present design, or one similar to it, taking particular care to assess these effects separately for A and B scores.

Conclusions and Recommendations

The results of each of the seventeen experiments which have been reported here have been discussed at some length throughout this report, both on an experiment by experiment basis and in relation to each other in the general discussion sections which concluded the three main subsections of the report. It seems unnecessary, therefore, to reiterate here the conclusions and recommendations which have already been made in the course of the preceding discussions. The emphasis here will be on the broader implications of the results of these studies.

Considering first the results for overall performance in our various experiments, it seems fair to say that input modality does not appear to be a particularly potent variable, at least under the present conditions where the durations of the aural and visual stimuli were equivalent. That is, the magnitudes of the differences in overall performance, measured by numbers of correct responses or numbers of trials to achieve a criterial level of performance, as a function of input modality were not large by absolute standards. Further, with the possible exception of serial learning with high $\underline{m}$ materials, performance under aural conditions was superior to that under visual conditions and vice versa about equally often across task situations. Similarly, in spite of the numerous occasions for modality to have interacted with other variables in our various experiments, it did so on only four occasions, three of these involving $\underline{m}$. Of particular significance in the latter connection is the fact that $\underline{S}$'s sex and input modality rarely interacted. Thus, four conclusions seem warranted based on the results for overall performance: (1) The laws governing the learning of verbal materials under aural conditions of reception parallel, with few exceptions, those governing learning under visual conditions of reception. (2) If a variable effects learning under visual conditions, the probabilities are high that it will do so under aural conditions. (3) The reception and processing systems of males and females do not appear to differ with respect to mode of input. (4) It seems doubtful that those differences in performance as a function of input mode identified here are such that they should be viewed as having serious practical consequences for learning in the classroom situation.

At a more theoretical level but continuing to consider gross overall performance, the results when considered in relation to the two phase conception suggest that input mode, if it had an effect at all, its effect was most likely to be confined to the associative phase of learning. This inference is based on the fact that in free-recall learning which may be regarded as an analogue of the response-learning phase no mode effect obtained in overall performance in any of four separate experiments (Cf., Exps. III, IX, XI and XII). Additional evidence favoring this inference comes from the results of Exps. VI, XIII and XIV where mode had an effect, or would be inferred to have had one (Exp. VI), and the tasks involved PA recognition or matching (associative phase only). Moreover, the finding of differences in the free-association response heirarchy under aural as opposed to visual conditions of reception in Exp. V suggests a possible mechanism for such effects at least in the case of materials varying in m.

Turning next to the more "molecular" analyses of performance which were carried out on the data of certain of our experiments, notably Exps. III, VI, IX and XVII, a number of potentially important dimensions of performance were seen to vary as a function of whether reception was aural or visual. Indeed, the evidence suggested that the storage mechanisms underlying memory for material received via the two modes of presentation may be different. For example, it seems highly probable that short-term immediate memory was superior under aural as opposed to visual conditions because aural inputs enter memory "directly" while visual inputs require "conversion" to an aural form. However, since most of the analyses of this type were ad hoc in nature, the conclusions based upon them must remain highly tentative until they have been independently verified in subsequent research designed specifically for this purpose. Moreover, in light of the limited success we had in identifying modality differences at more gross levels of performance, research at this more "molecular" level seems, at least from the present vantage point, to be preferable to continuation of the present approach.

In conclusion, it seems justified to maintain that substantial progress was made toward achieving two of three stated objectives of the present project. That is we know a good deal more than before about the learning of aurally received verbal material and how learning of this material under aural conditions compares with that under visual conditions of reception. Further, the latter seems to be the first large scale comparison of the two modes with stimuli of equivalent durations. Our initial priorities being what they were, concentration on the first two objectives, we were unable to achieve our third objective, the study of learning under conditions of joint aural and visual reception. Nevertheless, we believe that the likelihood of the future achievement of this objective has been incremented significantly by the present research.

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